Northeast Fisheries Science Center Reference Document 91-03

Report of the Twelfth Northeast Regional Stock Assessment Workshop (12th SAW)

Spring 1991

NOAA/National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole, MA 02543

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REPORT OF THE TWELFTH NORTHEAST REGIONAL STOCK ASSESSMENT WORKSHOP (12th SAW) Spring 1991

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TABLE OF CONTENTS

SUMMARY

The 1991 Spring Northeast Regional Stock Assessment Workshop (Twelfth SAW) took place in Woods Hole, Massachusetts in two sessions. The Stock Assessments Review Committee (SARC) session was held 3 - 8 June and the Plenary, 10 - 12 July 1991. A total of ninety-three individuals from thirteen organizations, attended all or parts of the sessions (Table 1). Organizations represented were: the States of Massachusetts and New York, Manomet Bird Observatory, Virginia Institute of Marine Science, Conservation Law Foundation, Canadian Department of Fisheries and Oceans, Atlantic States Marine Fisheries Commission, the New England and Mid-Atlantic Fishery Management Councils; and the Northeast Regional Office and Southwest, Southeast, and Northeast Fisheries Centers of the National Marine Fisheries Service.

The objective of the SARC was to provide a thorough technical review of submitted analyses for Northwest Atlantic mackerel, Atlantic Butterfish, Gulf of Maine cod, yellowtail flounder, short and long fin squid, and Atlantic sea scallops. The SARC sought to determine the best current assessment of the resource, major sources of uncertainties in each assessment, and how uncertainties may affect stock status. The product of the SARC is the **Stock Assessment Review Committee Consensus Summary of Assessments.**

A major objective of the Plenary was to prepare the **Advisory Report on Stock Status** based on the SARC report. The Advisory Report contains a summary of stock status and recommendations of the Plenary and is intended to serve as scientific advice for fishery managers on resource status.

Special topics at the Plenary included reports of the Sea Sampling Analysis, Lobster, and Squid Working Groups; presentations on Survey Vessels and Gear Modifications and Their Possible Effects on Assessment Analyses; and panel presentations and discussion of Design of Data Access and Analysis Systems -- Commercial, Recreational, Survey, and Sea Sampling. Discussion of these topics resulted in the formation of two new working groups (Adequacy of Biological Sampling and Recreational Fisheries Statistics), new terms of reference for the Sea Sampling Analysis Working Group, and the recommendation to review the NEMFIS (Northeast Marine Fisheries Information System) and data systems of the NMFS Northeast Regional Office, the New England and Mid-Atlantic Fishery Management Councils, and the Atlantic States Marine Fisheries Commission.

The Plenary suggested, for SAW Steering Committee consideration, nine species/stocks to review at the next SARC session and concluded to establish a SAW Research Document Series from the working papers submitted to the SAW sessions.

It was recommended to hold the next, SAW-13, Stock Assessment Review Committee Meeting during the first week of December 1991 and the Plenary, 7 - 9 January 1992.

Table 1. List of participants.

<u>National Marine Fisheries Service</u>

Northeast Fisheries Center

Frank Almeida
Vaughn Anthony
Kathryn Bisak
Solange Brault
Jon Brodziak
Jay Burnett
Nicole Buxton
Charles Byrne
Jack Casey
Darryl Christensen
Steve Clark
Ray Conser
Steve Edwards
Christine Esteves
Michael Fogarty
Janice Forrester
Kevin Friedland
Wendy Gabriel
John Galbraith
Patricia Gerrior
Ron Goldberg
Dennis Hansford
Daniel Hayes
Joseph Idoine
Ambrose Jearld, Jr.
Robin Jenness
Paul Kostovick
Philip Logan
Ralph Mayo
Margaret M. McBride
Bill Michaels
Tom Morrissey
Nancy Munroe
Steve Murawski
Robert Murchelano
Helen Mustafa
Loretta O'Brien
Bill Overholtz
Debbie Palka
Joan Palmer
Linda Patanjo
Jack Pearce
Alex Penkrat
Allen Peterson
Barbara Pollard
Greg Power
Anne Richards
Andrew Rosenberg
Cheryl Ryder
Ronnee Schultz
Fred Serchuk
Gary Shepherd
Malcolm Silverman
Tim Smith
Katherine Sosebee
Chuck Stillwell
Mark Terceiro
John Walden
Gordon Waring
Susan Wigley
Patricia Yoos

Northeast Region

Peter Colosi
Hannah Goodale
David Ham
Pat Kurkul
Gregory Mannesto
Bob Pawlowski
Kathi Rodrigues
Jack Terrill
Stanley Wang

Southeast Fisheries Center

Gerald Scott

Southwest Fisheries Center

Robert Kope

DFO/B10 Dartmouth N.S.

Christina Annand

Mid-Atlantic Fishery Management Council

Tom Hoff
Dave Keifer

New England Fishery Management Council

Andrew Applegate
Lou Goodreau
Philip Haring
Chris Kellogg
Pamela Mace
Howard Russell

Atlantic States Marine Fisheries Commission

Paul Perra

Massachusetts Division of Marine Fisheries

Steven Correia
Thomas Currier
Bruce Estrella
Arnold Howe
Daniel McKiernan
David Pierce
David Witherell

New York Department of Marine Resources

John Mason

Monomet Bird Observatory

Friedrich Von Krusenstiern
Jay Wennemer

Conservation Law Foundation

Eleanor Dorsey

College of William and Mary VIMS

Jim Kirkley

THE PLENARY

INTRODUCTION

The Summer 1991 Northeast Regional Stock Assessment Workshop (Twelfth SAW) Plenary was held in Woods Hole 10 - 12 July 1991. The Plenary agenda is presented in Table P1. Although papers did not accompany all presentations, nine working papers were submitted to this session (Table P2). The session was attended by more than 70 individuals from a number of institutions in the Northeast and the Mid-Atlantic. This report summarizes the special topics discussed in addition to the **Advisory Report on Stock Status.**

The Plenary heard six presentations during the Sea Sampling Analysis Working Group report, presentations of the results of Lobster and Squid Working Groups, and three papers during the topic on Survey Vessels and Gear Modifications and Their Possible Effects on Assessment Analyses. A panel of four addressed commercial, recreational, survey, and sea sampling aspects under the topic of Design of Data Access and Analyses Systems after which participants joined in to further discuss the adequacy of current data structures and analysis procedures.

On the last day of the session, the Plenary suggested for SAW Steering Committee consideration nine species/stocks to review at the next SARC and several topics for the next Plenary, set terms of reference for working groups, identifying a need for two new ones, and concluded that SAW-13 should take place during December and January. As an additional topic, Documentation, of concern not only to the users of SAW documents but to the contributors as well, was discussed and it was concluded that there will be a SAW Research Document Series developed from the working papers presented during the meeting of the SARC and the Plenary.

Table P1.

12th NORTHEAST REGIONAL STOCK ASSESSMENT WORKSHOP

PLENARY

Carriage House, Quissett Campus
Woods Hole, Massachusetts

July 10 - 12, 1991

AGENDA

Moderator		A. Rosenberg
Wednesday, July 10		
9:30	Opening Remarks	J. Pearce
9:50	Chairman's Remarks Review Agenda Review Activities Steering Committee, Working Groups, etc.	A. Rosenberg
10:15	Coffee	
10:30	SARC Report	A. Rosenberg
12:00	Lunch	
1:30	Advisory Report on Stock Status Discussion and Preparation	
Thursday, July 11		
9:00	Review and Complete Advisory Report	A. Rosenberg
9:45	Results of Sea Sampling Analysis W.G.	
	Overview	D. Christensen
	Bycatch and discard patterns in the Gulf of Maine northern shrimp fishery	S. Clark
	Combining sea sampling data with other sources of discard information to estimate discarded numbers at age - an example using yellowtail flounder	W. Overholtz R. Conser A. Rosenberg
10:45	Coffee	

Table P1 (Continued)

11:00	Exploratory analysis of four methods for estimating discards from sea sampling data	D. Hayes
	Bootstrap estimators of discard rates using domestic sea sampling data	J. Brodziak
	Cod discards in the Gulf of Maine fisheries: an exploration of the sea sampling data base	S. Wigley
11:45	Discussion	
12:00	Lunch	
1:00	Design of Data Access and Analysis Systems -- Commercial, Recreational, Survey, Sea Sampling	S. Murawski S. Clark D. Christensen M. Terceiro
2:00	Discussion of adequacy of current data structures and analysis procedures	
3:00	Coffee	
3:15	Survey Vessels and Gear Modifications and Their Possible Effects on Assessment Analyses	C. Byrne J. Forrester

Friday, July 12

9:00	Results of the Lobster Assessment W.G.	J. Idoine
9:45	Results of the Squid Working Group	D. Keifer J. Brodziak
10:30	Coffee	
10:45	Terms of Reference and Timing	
11:15	Other Business	
11:45	Closing Remarks	A. Rosenberg

Table P2.

SAW 12 PLENARY PAPERS

SAW/12/Pl/1	Report of the 12th Regional Stock Assessment Workshop Stock Assessment Review Committee: Consensus Summary of Assessments	A. Rosenberg, SARC Chair
SAW/12/Pl/2	Exploratory Analysis of Four Methods for Estimating Discards from Sea Sampling Data	D. Hayes
SAW/12/Pl/3	Bootstrap Estimators of Discard Rates Using Domestic Sea Sampling Data	J. Brodziak
SAW/12/Pl/4	Cod Discards in the Gulf of Maine Shrimp Fishery: An Exploration of the Sea Sampling Database	S. Wigley
SAW/12/Pl/5	Relative Fishing Power of NOAA R/Vs Albatross IV and Delaware II	C. Byrne J. Forrester
SAW/12/Pl/6	Relative Fishing Power of Two Types of Trawl Doors	J. Byrne R. Forrester
SAW/12/Pl/7	By-Catch and Discard Patterns in the Gulf of Maine Northern Shrimp Fishery	S. Clark G. Power
SAW/12/Pl/8	Research Evaluation of Reporting Requirements for Various Fleet Components of Squid Fisheries	Squid W.G. T. Hoff, Chair
SAW/12/Pl/9	Minutes of Lobster Scientific Working Group Meeting 10-11 October, 1990	Lobster W.G. J. Idoine,Chair

RESULTS OF SEA SAMPLING ANALYSIS WORKING GROUP

The sea sampling topic focused on three areas: (1) an overview of the domestic sea sampling program; (2) preliminary statistical analyses of discard data collected by the domestic sea sampling program; and (3) terms of reference.

Program Overview

Darryl Christensen, Chairman of the Sea Sampling Working Group provided an overview of the domestic sea sampling program. The program was created in 1989 to collect data on discards of commercially important fish species from fisheries working Georges Bank and the Gulf of Maine. The program has been expanded since then to include the mid-Atlantic area and to document incidental takings of marine mammals, particularly in the gillnet fisheries. Additional coverage of the mid-Atlantic trawl fishery is projected in order to document takings of sea turtles. At-sea observers are used to collect data.

Sea sampling effort is allotted in terms of days that observers spend at sea, or sea-days. For the 1991 calendar year, 1955 sea-days are projected, including 940 days to help satisfy requirements of the Marine Mammal Protection Act. Through June 30, there have been 560 sea-days, including about 260 for marine mammal coverage. Sea-days increase from roughly 60 per month between January and May to over 200 days per month projected for the summer and fall.

In the absence of a statistical protocol, sea-days have been allocated among fishing gears on an ad hoc basis in an attempt to satisfy the immediate needs of users. The following seven gears have been sampled: (1) otter trawl; (2) sink gillnet; (3) drift gillnet; (4) fish pots; (5) lobster pot; (6) pelagic longline; and (7) bottom longline. Scallop dredge trips will be added in October, 1991.

Discard data are recorded for each tow. Data on the total weight of discards by species are available from January, 1989 through March, 1991 for otter trawl, sink gillnet, and drift gillnet gears. Length frequency data on discards are available from January, 1989 through December, 1990. Software to enter discard data from the fish pot, lobster pot, pelagic longline, and bottom longline fisheries was received in July, 1991.

A new contract for sea sampling has undergone extensive review by the Inspector General of the Department of Commerce. Proposals are now being reviewed. A continuation of 1000 sea-days per year is projected. Marine mammal and sea turtle coverage will augment this coverage.

Statistical Analyses

Population biologists from the Northeast Fisheries Center (S. Clark, W. Overholtz, R. Conser, A. Rosenberg, S. Wigley, J. Bordziak, and D. Hayes) presented five talks related to whether and how discard data from the sea sampling program can be used to improve the accuracy of stock assessments. Members of the Working Group explored a range of techniques for analyzing the sea sampling data. It is clear that information on discarding practices needs to be included in future assessments and that methodology work must continue. Although there has been some notable success with the yellowtail flounder assessment, each species may need to be treated differently to make the most of available information.

One talk addressed whether using discard data from different sources to build a catch-at-age matrix would introduce bias into stock assessments (see SAW/12/SARC/12). Ignoring discards as a source of fishing mortality will bias estimates of stock production. Sea sampling is expected to provide better data on discarding than do dockside interviews of captains and the Center's population surveys, but the sea sampling program did not begin until 1989.

To test this question, discard data on Southern New England yellowtail flounder from the three sources were combined to calculate retention proportions. (A retention proportion was defined as the fraction of total catch, including discards, that is landed by age, quarter of year, and cohort.) Retention proportions were then tested for the effects of year, age, and data source using ANOVA. The null hypothesis that data source had no effect on retention proportion could not be rejected, suggesting that the three data sources can be combined.

A second talk reported on discards of groundfish in the Gulf of Maine northern shrimp fishery (SAW/12/Pl/7). The purpose of this talk was to evaluate discard with reference to spatial and temporal distribution of sea sampling effort.

Fishing effort and landings vary in proportion to the availability of shrimp during the December-May season. Seasonal shifts in effort occur in response to inshore-offshore movements which appear to have a significant impact on amounts of finfish discard. Fishing effort is clustered near ports of origin in three zones--central Maine, southern Maine, and New Hampshire-Massachusetts. Seasonal trends in (landed) by-catch of finfish relative to shrimp landings differ between these areas.

For 1990 sea sampling trips, groundfish discards as a percentage by weight of total shrimp landings differed among fishing areas, with southern Maine being the highest at 74%. Most of the groundfish by-catch was discarded in each fishing zone, including about 90% by weight of the total catch of American plaice and 70% by weight of the total cod catch.

Total discards in 1990 were estimated by multiplying monthly estimates of discards per day fished from the sea sampling database by corresponding fishing effort totals from the weighout database. This procedure yielded estimates of 5.7 million pounds of finfish, including 1.2 million pounds of cod (1 million fish) and 1.5 million pounds of American plaice (1.5 million fish). It was concluded that the groundfish discard problem in the northern shrimp fishery is significant, although it was noted that coverage was limited and did not appear to be truly representative for at least one of the three areas considered. Accordingly more work will be necessary before we can be confident of our estimates for this fishery. In the future, sampling work allocation of sea-days in the sea sampling program should match the distribution of fishing effort by area and month, including the inshore fleet of small vessels for which coverage appears to have been very low.

A third talk concentrated only on the estimation of cod discards in the Gulf of Maine northern shrimp fishery (SAW/12/Pl/4). In this case, though, multiple regression analysis was used to estimate total discards in 1989 and 1990 using data from the sea sampling data base.

A multiple regression model was developed in which tow duration, shrimp landed, and an interaction term involving month and the ratio of cod caught to shrimp landed explained 63% of the variation in cod discards in sea-sampled tows. Cod discards in the fishery were estimated to be about 200 thousand pounds during the 1989 and 1990 shrimp seasons. This figure is only about 20% of the estimate generated from the previously discussed ratio estimator.

The remaining two papers focused more on the performance of other estimators of discards. In one (SAW/12/Pl/3), the bootstrap methodology was explored as a means to estimate discards in a fishery. An advantage of bootstrapping is that it can be applied effectively to small data sets when little is known about the distribution of a target parameter, such as discard rate.

Two bootstrap estimators were developed and applied to 1989 sea sampling data on landings and discards of cod, haddock, and yellowtail flounder in the large mesh otter trawl fishery in the Gulf of Maine. The "aggregate ratio estimator" was defined as total landings or discards of a species from all tows during the sampling period (quarter of the year, in this case) divided by the sum of the tow durations. In contrast, the "average rate estimator" was the un-weighted average of landings or discards per unit time of a tow.

Known properties of the estimators and their performances when applied to estimate actual landings and discards from the sea sampling data base suggest that the aggregate ratio estimator would be more precise and accurate than the average rate estimator. However, when tested against fishery data (vis-a-vis the population of sea sampled trips), both estimators substantially underestimated estimates of total landings of cod and yellowtail flounder. In contrast, both estimators produced 95% confidence intervals that included actual haddock landings.

These results suggest that discard rates of cod and yellowtail flounder which are estimated from sea sampling data using either ratio estimator may underestimate actual discards of some species in the fishery. These results further suggest that the procedure used to select vessels and/or trips during a quarter for sea sampling are not representative of the fishery.

In contrast to the above focus on species caught by one gear, a second paper on estimators addressed discards of only cod by vessels using either large mesh trawls, small mesh trawls, gillnets, or shrimp trawls in the Gulf of Maine (SAW/12/Pl/2). In addition, the estimators presented in this talk were based on the clustered nature of the observations, recognizing that the tows observed during a trip are not independent, random samples of all tows in a fishery. Furthermore, the specter of censorship is raised because not all tows during a sea sampled trip are necessarily sampled.

This talk focused in part on the coincidence between assumptions of an estimator and the way observations in the sea sampling data base were selected. The two cluster sampling estimators require that the basic observational unit be a random sample of tows within a trip and that trips be randomly selected from the entire population of trips within a fishery. The first cluster estimator of total discards results in a formula that multiplies the total trips in a fishery by the un-weighted average of the estimate of total discards per trip sampled. The second estimator uses the same assumptions about how observations are selected, but it is based on the number of days fished rather than trips and takes the form of a ratio estimator.

The other two estimators in this paper were univariate linear regression estimators. These assume that the observations on tows are an independent random sample of all tows made in the fishery with respect to the relationship between discard rate and landings. As above, the regression estimators differed by the measure of fishing effort--days fished or fishing trip.

There was no apparent pattern of predictions of discards across estimators or fisheries. Estimates of discards produced by the cluster estimators were quite different from regression estimates. In addition, the cluster estimators yielded similar estimates of discards in the large mesh and small mesh fisheries, but the estimates differed by a factor of five in the shrimp fishery. Similar conclusions can be drawn from a comparison of the results from the two regression estimators.

There was even less agreement between predictions of total landings yielded by the cluster estimators. Furthermore, although cluster sampling appeared to have a lower coefficient of variation than regression estimators, the cluster estimates of total landings differed by up to an order of magnitude from actual landings in each fishery. This disagreement implies that the selection of tows by the sea sampling program is not random.

In addition to comparing the performance of estimators, the relationships between sample sizes and precision of estimates of cod discards were illustrated for the first cluster sampling estimator. For example, a 20% coefficient of variation would require coverage of about 200 trips in the large mesh and gillnet fisheries (PA1a and PA1b), about 150 trips in the small mesh fishery (Figure PA2), and about 110 trips in the shrimp fishery (Figure PA3). In this case (and in the context of measuring cod discards), the large mesh otter trawl and shrimp fisheries were under-sampled.

The five talks provoked similar discussions. Whereas it was widely understood that a statistically valid sampling procedure for the sea sampling program could not have been envisioned in 1989, there are now sufficient data to begin to improve upon the ad hoc allocation of samples.

Much of the discussion centered on the representativeness of the discard samples. Beyond the possible need to improve upon precision, there was great concern about the accuracy of estimates. The correspondence between the distribution of sea samples and the heterogeneity of stock abundance and fishing effort in space and time and among vessel characteristics (particularly gear and vessel class) was addressed in the northern shrimp talk and commented on in discussions of most other talks. It was agreed that the troubling disparity between actual landings and estimates made by extrapolating results from sea sampling data base could be narrowed by random sampling and larger sample sizes. The working group was reminded, however, that sample sizes and coverage are subject to budget and contract constraints.

The talks and discussion also illustrated how little is known about the appropriate choice of estimator(s). The variety of estimators reported in the talks (ratio, regression, and clustered estimators) was matched by the range of estimates of discards and landings. For example, estimates of total discards of cod in the northern shrimp fishery ranged from 200 thousand pounds in the multiple regression talk to between 40 thousand (SAW/12/P1/4) and 500 thousand pounds in the talk reporting on clustered and regression estimators to 1.2 million pounds in the talk on by-catch and discard patterns (SAW/12/P1/7).

Related to the choice of estimators is a host of issues concerning how an estimator should be applied. First, there was some discussion of what the unit of effort should be, in terms of both assumptions of an estimator and matching estimates of discard rates with fishery data. Thus, should estimates of discard rates be made in terms of tow duration, day-fished, day-absent, or trip? Second, factors which are implicitly held constant but which may change from year to year in ways that affect discards should be kept in mind. For example, strength of a year class, regulations on fish size, fishing technology, and ex-vessel prices were not controlled in the reported studies, but they could affect discard rates. Also with regards to the linear regression estimator, there is a choice of model specification even within season as evidenced by reports of univariate and multivariate models. Finally, the procedure used to estimate a discard rate model may have to be able to handle truncation (e.g., zero discards during a tow) or censorship (e.g., missed tows).

Plenary Conclusion

The participants agreed that substantial progress had been made in working with this complex data base. Although these exploratory analyses did not lead to clear conclusions on how to estimate discards, they have revealed some important properties of the data and made an important contribution toward this problem.

The reports and discussion directed attention on four topics that were selected as terms of reference for the sea sampling working group:

1. Determination of sample sizes with particular attention paid to precision, selection of more species and fisheries, and further analysis of the 1990 data base;

2. Representativeness of samples with regards to the accuracy of discard estimates that reflect the spatial, temporal, and technological heterogeneity of fisheries;

3. The properties of estimators in theory, simulations, and practice.

4. Comparison of sea sampling data and other sources of information, e.g., interviews, or discard rates for a variety of species.

It was suggested that the Sea Sampling Working Group meet soon to divide into sub-groups for work on these terms of reference. Given the massive undertaking, it appeared unlikely that the Working Group can report to the next SAW on all of these topics.

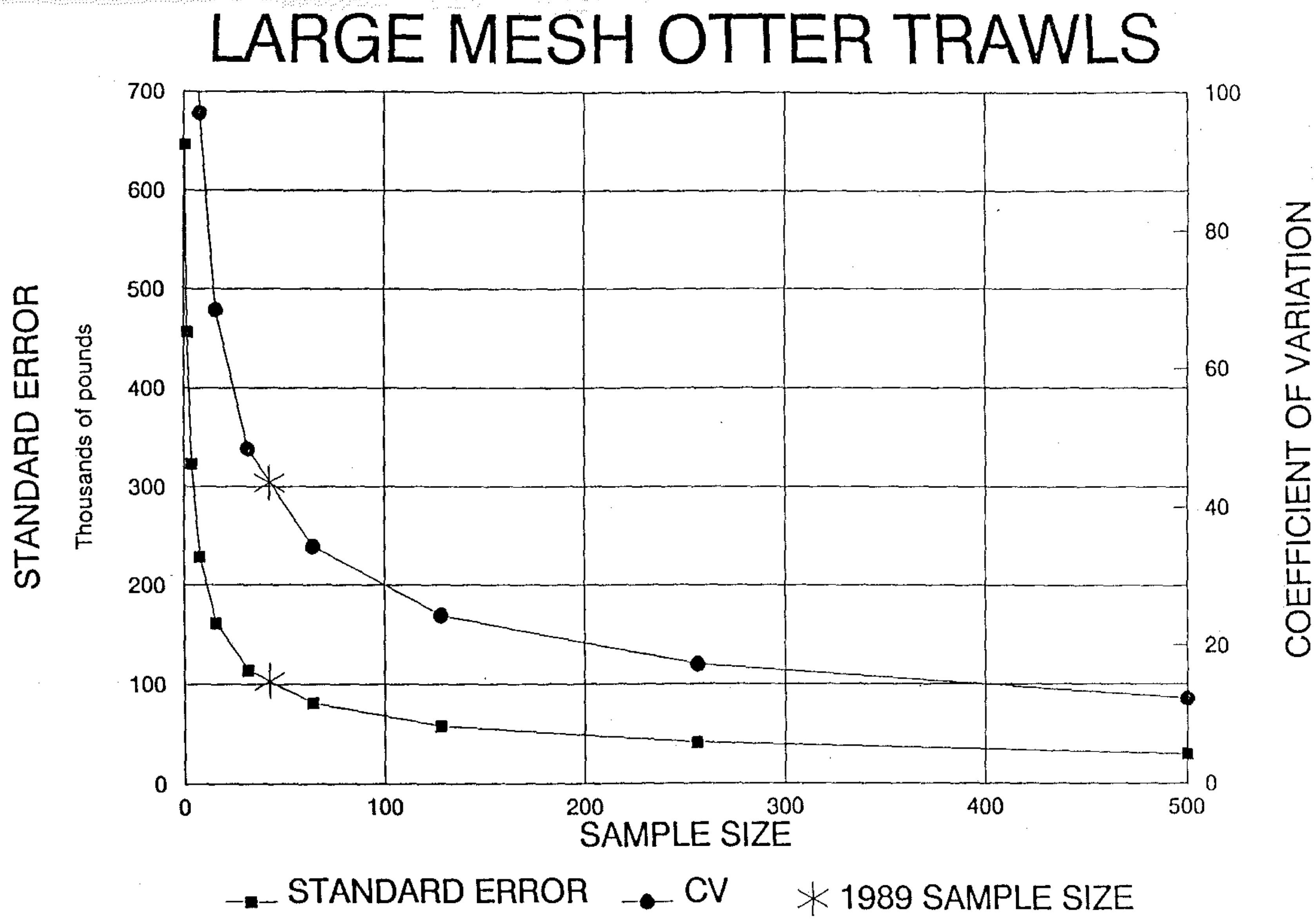


Figure PAla. Approximate standard and coefficient of variation obtainable with different sample sizes (trips) for the large mesh otter trawl fishery in the Gulf of Maine, based on 1989 data.

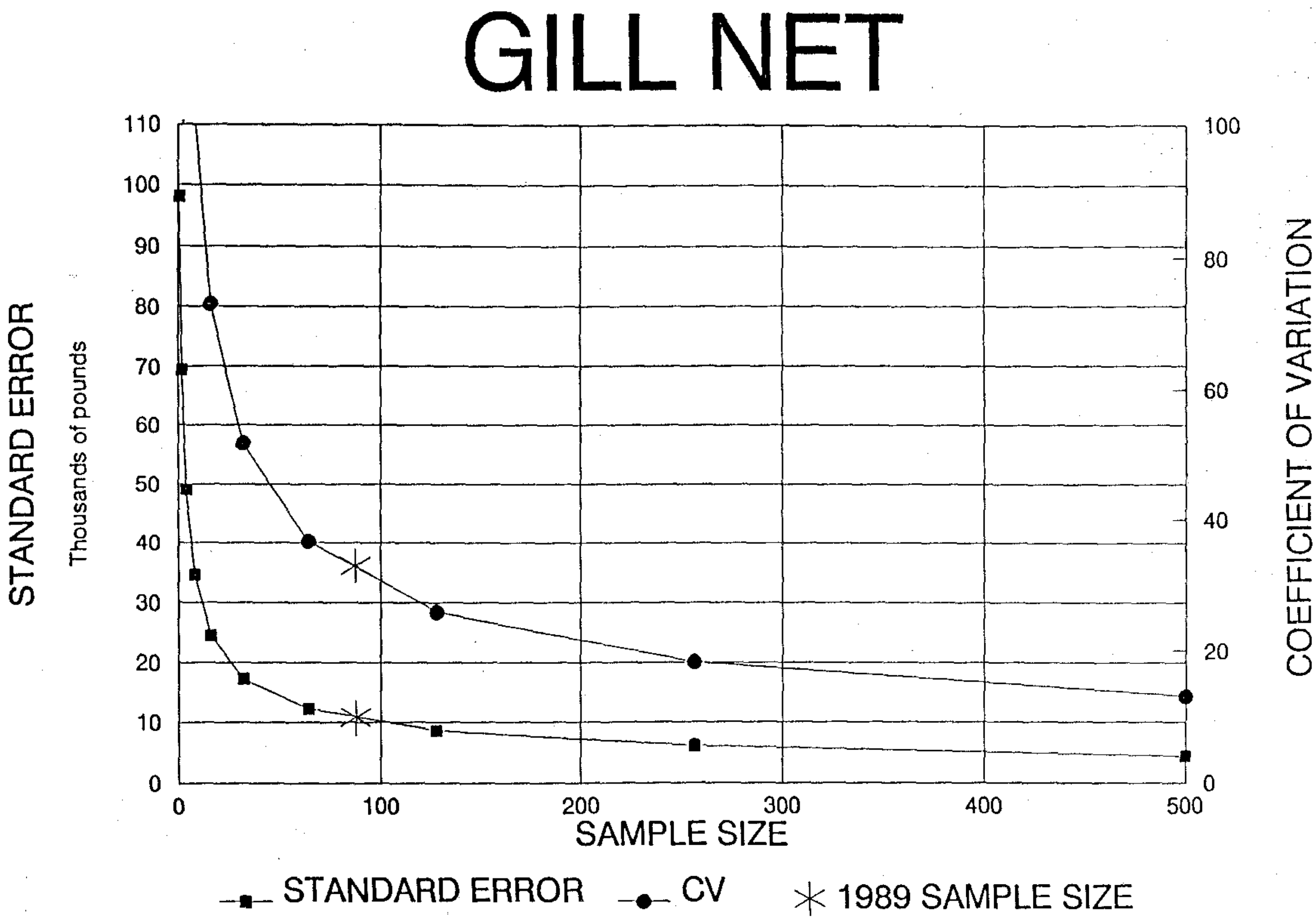


Figure PA1b. Approximate standard and coefficient of variation obtainable with different sample sizes (trips) for the gillnet fishery in the Gulf of Maine, based on 1989 data.

SMALL MESH OTTER TRAWLS

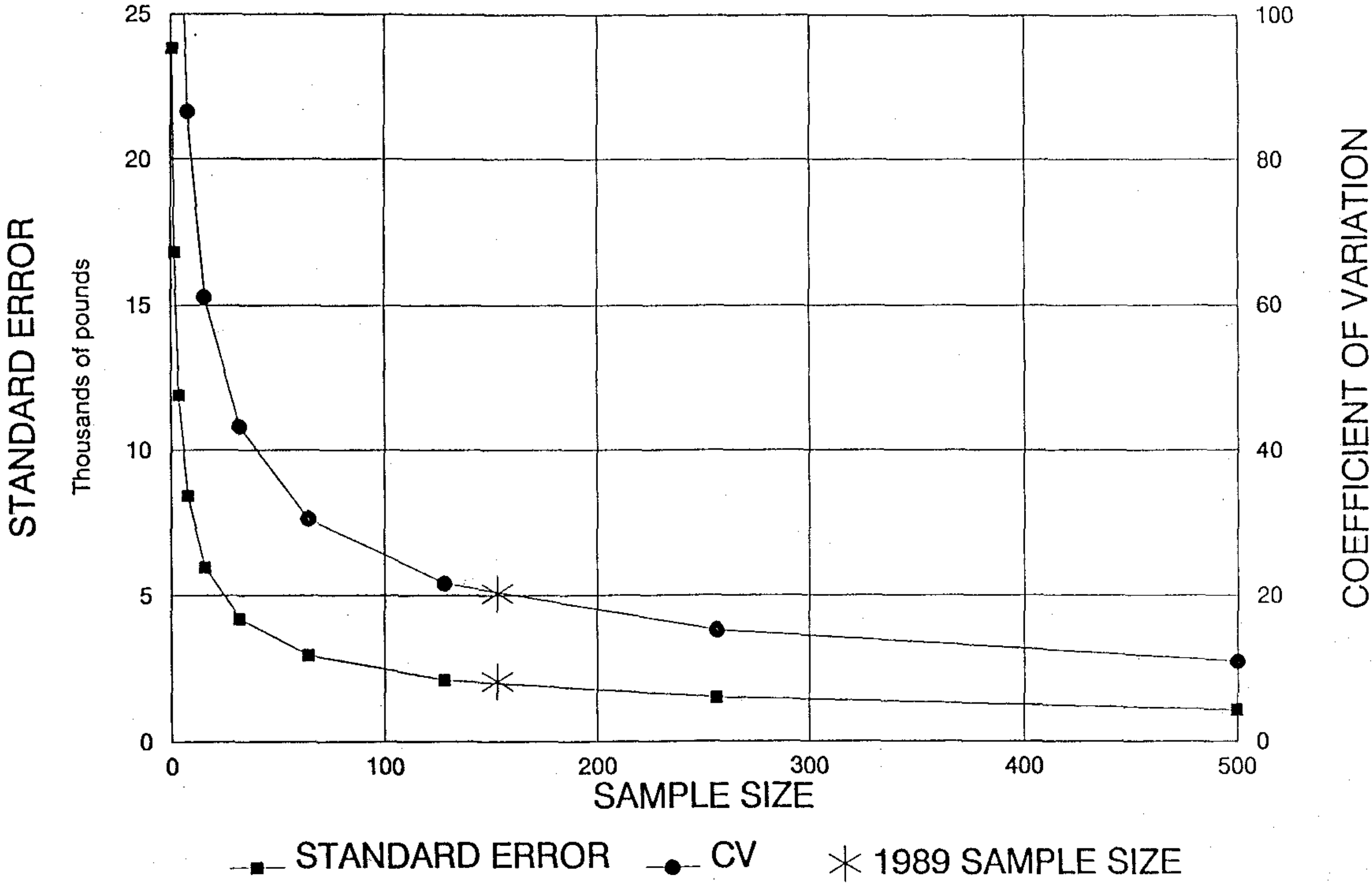


Figure PA2. Approximate standard and coefficient of variation obtainable with different sample sizes (trips) for the small mesh otter trawl fishery in the Gulf of Maine, based on 1989 data.

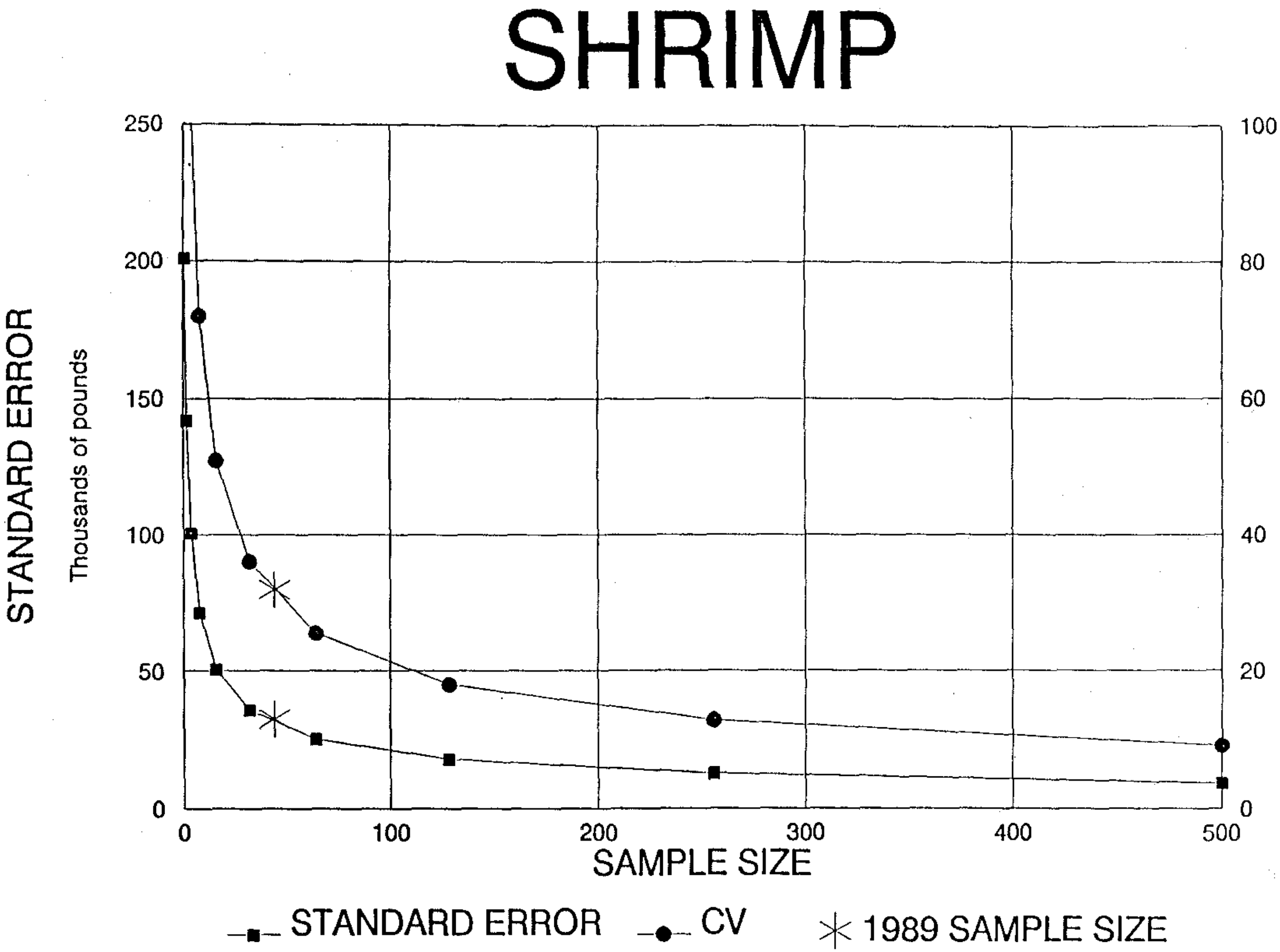


Figure PA3. Approximate standard and coefficient of variation obtainable with different sample sizes (trips) for the shrimp fishery in the Gulf of Maine, based on 1989 data.

DESIGN OF DATA ACCESS AND ANALYSIS SYSTEMS – COMMERCIAL, RECREATIONAL, SURVEY, SEA SAMPLING

The discussion of this topic was lead by S. Murawski, S. Clark, D. Christensen, and M. Terceiro of the Northeast Fisheries Center.

Overview

Steve Murawski presented an overview based on discussions at the Stock Assessment Review Committee meeting. Emphasis of the overview was on new computers and software, new types of analyses requested by Fishery Management Councils, and new or revised data collection methods.

Four areas of concern were outlined:

1. Analytical requirements for assessments and scenario analyses.

   Needs include more disaggregated approaches to data analyses, more statistically based approaches to VPA tuning, more flexibility in analyses, and methods for integrating newer data sets (i.e. sea sampling, recreational, etc.) into assessment analyses.

2. Coordination of access to and analysis of data among various user groups (States, Councils, NERO, etc.)

   Coordination of assessment inputs for joint evaluations would require training the users to access and properly interpret the content of data sets. Feedback from the users to the database managers and collectors should be encouraged to eliminate ambiguities in data content and data base design.

3. New data/series not currently collected, archived or accessible on computers.

   New data sets, (i.e. new economic data currently being collected under the domestic sea sampling, recreational data, and new survey data) should be on the computer in formats that makes analysis and access easier and more flexible.

4. Feedback in data collection programs.

   Better defined and more consistent feedback is needed from the assessment scientists and Councils staff to data collectors so that priorities for collecting information can be more adequately defined.

In discussion, the need to improve economic and recreational fisheries statistics was emphasized, and questions were raised on what to collect and how to make information available.

Questions on fisheries to target in the domestic sea sampling program, needed surveys, and needed improvements or modifications to existing programs were raised during a discussion on feedback in data collection programs. Discussed also was the need for better monitoring of all data collection programs and how much data is enough.

NEFC Resource Survey Program

Steve Clark indicated that funding from the Gulf of Maine program, is making it possible for the Population Biology Branch to upgrade its resource survey program. Efforts are being made to improve current data collection procedures, to implement new surveys, and to upgrade existing technology. Data collection procedures that are being evaluated this summer, include a revised biological sampling protocol, repeated sub-sampling at every station, and eliminating remeasuring of fish during the dissection phase.

Two new surveys are currently planned which will lead to new survey time series. The Gulf of Maine summer inshore survey will have a new sampling design influenced by input from the fishing industry. The winter flatfish survey for Southern New England and Georges Bank will have a new design and gear configuration (chain sweep gear to improve the trawl's effectiveness for flatfish).

Technology upgrades in progress include the use of dual range compensating scales for at sea weighing, acquisition of conductivity-temperature-depth profile instruments, and improved trawl mensuration gear.

Several database improvements are in progress. The 1982 to present station data is being re-audited with improved database management software. All fields are being checked. The historical time series, 1963 to 1981, (old 80-column format) has been corrected, revised and keypunched, and auditing is underway. All trawl logs have been placed on microfilm.

Progress is also being made on data access and analysis. Plans are being developed for analytical software improvements (SURVAN, SPDIS, etc.). Geographical information system software has been ordered for the proposed LAN (Local Area Network), and software for automated station selection and plotting (including digitized stratum boundaries) are nearly complete.

Discussed were problems associated with the access to and availability of data sets as well as computers. NEFC ordered LAN work stations. It is planned to test CYBASE as a database manager using the domestic sea sampling data set on the LAN. As users of the system will require training, the Plenary encouraged coordination with users and the participation of the Councils, as well as other users from the beginning of the activity.

Noted was the need for more surveys at different times of the year and use of survey data outside the realm of traditional uses (e.g., a recent yellowtail flounder assessment), as well as the importance to continue to expand the survey to meet more analytical needs. Recognizing that trawl changes will inevitably have to be made, it was suggested to do this as soon as possible to maximize long term benefits and noted that the overall effectiveness of gear may need to be examined.

Commercial Fisheries Data Base

Darryl Christensen emphasized that the commercial fisheries database is designed to meet the needs of a variety of users. First priority of the database is to meet the reporting requirements set forth in the Magnuson Fishery Conservation and Management Act. Users outside the Center include Fishery Management Councils, assessment scientists, universities, news media, economists, consulting firms, fishing industry, etc.

Because there are many users of the database, issues raised by the Plenary concerned easier access, a system for documenting data idiosyncracies, system limitations, and confidentiality.

Use of Recreational Data in Assessments

Mark Terceiro discussed how recreational data are currently used in the assessment of bluefish and summer flounder. Data from the Marine Recreational Fishery Statistics Survey (MRFSS) is available for 1979 to 1989. Success has been made in merging the recreational length frequency data with comparable data from the commercial and survey data sets in these assessment analyses.

Major points discussed included the need to document methods for assessment type access, need to document ageing problems, and the need to extract statistics currently available from the MRFSS (Marine Recreational Fisheries Statistics System). Access to this database for analytical purposes must be much broader in order to assess the importance of recreational landings in a number of fisheries.

Plenary Conclusion

Although the formation of a working group to address computer and data access issues was discussed, the Plenary decided against this for the time being and concluded that the topic will remain on the agenda of the next SAW. An overview of the NE Marine Fisheries Information System (NEMFIS) and updates on NMFS NE Regional Office, Councils, and ASMFC systems, noting any redundancy among them, should accompany the presentations under this topic.

It was recommended to establish a working group to address the problems associated with recreational fisheries statistics. Paul Perra (ASMFC) was suggested as Chair and Tom Morrissey (NEFC) to assist in coordination among the various organizations and the Northeast Fisheries Center.

SURVEY VESSELS AND GEAR MODIFICATIONS AND THEIR POSSIBLE EFFECTS ON ASSESSMENT ANALYSES

Presentations on this topic were made by C. Byrne, J. Forrester (SAW/12/Pl/5 and 6), and D. Hayes.

The first part of this presentation described fieldwork, data sets, and analyses employed to determine effects of changes in vessel and gear configurations within the NEFC bottom trawl survey time series. Vessel fishing power studies were necessary due to the use of the R/V DELAWARE II when the R/V ALBATROSS IV was unavailable, and exclusively since decommissioning of the ALBATROSS IV in 1989. The two vessels were also used jointly in some years to improve synopticity. ALBATROSS IV is scheduled to return to service in late autumn of 1991. Five paired-tow experiments were undertaken to evaluate vessel fishing power differences. In each case, DELAWARE II accompanied ALBATROSS IV during a standardized bottom trawl survey; standard survey procedures were used to collect and archive the resulting data. Mid-Atlantic, Southern New England, Georges Bank, and Gulf of Maine strata were covered in these experiments, resulting in a total of 510 paired tows for analysis.

A second series of experiments was conducted to evaluate the effects of changes in trawl doors on survey catch rates. In 1983, production of our standard (BMV) doors by the original Norwegian supplier was discontinued and no alternate supplier could be found. Based on size, weight and design characteristics, a polyvalent door manufactured in Portugal was selected as the replacement and was introduced to the survey in 1985. Experiments to compare and standardize the relative fishing power of BMV and polyvalent door trawls were initiated in 1984. Except where constrained by operational difficulties, these have employed an experimental grid design in which the two door types are alternated over a two day period between 4 six-hour time frames, 4 tows being taken in each time frame, e.g., BMV doors used from 6 am to noon on Day 1 and polyvalent doors from 6 am to noon on Day 2. All other factors were held constant. This arrangement permitted analysis by randomized block or paired tests. To date, 8 experiments have been completed, primarily in the southern New England and Georges Bank region, resulting in a total of 345 paired tows for analysis. Additional experiments are scheduled in autumn and winter of 1991-92 in the Middle Atlantic and the Gulf of Maine.

For species with 15 or more pairs of tows in which individuals were caught in each tow (termed "non-zero" pairs) data were transformed to natural logarithms. Paired t-tests were then employed to test for vessel and door effects. Where significant differences ($P<0.05$) were found, means were re-transformed back to the original scale to provide unbiased estimators of the vessel or door conversion coefficient and an approximate 95% confidence limit calculated using the "bootstrap" method.

For vessel effects, consistent differences ($P< 0.05$) were not observed for individual species either within or among cruises, although catches in terms of total number and weight were almost invariably higher for the DELAWARE II. To increase the power of the tests data were pooled over cruises (different doors were used in the vessel effects time series and different vessels in the door effects time series, but no evidence for cruise-door interactions was found in either case.) Of the 50 species tested, significant differences were found for numbers and/or weight for 27 in the pooled tests (Table PC1). For tests in which less than 30 pairs of tows were available results should be viewed with caution, since the paired t-test is less robust to normality in such situations. Overall conversion coefficients for DELAWARE II relative to ALBATROSS IV were 0.85 for numbers and 0.80 for weight. These differences may relate to differences in winching speed between the two vessels (ALBATROSS IV is able to set and retrieve gear more quickly). Also, an eleven foot long trawl door backstrap extension is required on DELAWARE II because of its stern configuration which may create a "herding" effect.

For door effects, 42 species were tested, of which significant differences were found for 15 in terms of numbers and/or weight as well as for all species combined Table PC2). Again, results should be viewed with caution in some cases due to low sample size. In almost all cases where significant differences were detected, catches were higher for the polyvalent doors. Field observations and measurements with SCANMAR trawl mensuration gear suggest that these doors tend bottom better and provide a wider wingspread and lower headrope height compared to the BMV doors.

Overall conversion coefficients for the BMV doors relative to the polyvalent doors are 1.28 for numbers and 1.41 for weight. Examination of the data for cod (for which the calculated coefficients were among the highest) for three length groups (<20 cm, 20-40 cm, and >40 cm) revealed a significant difference only for the latter group.

The latter part of this session involved a review of analyses conducted by Daniel Hayes (NEFC) on an example stock to illustrate the effects of the door conversion coefficient on VPA tuning with the Laurec-Shepherd method. Analyses included a base run (no door conversion coefficient), a series of runs in which the coefficient was incremented from 1.1 to 1.9 at intervals of 0.2 (Figure PC1), and runs in which commercial CPUE indices were incorporated along with the survey indices. Outputs included estimates of stock size at age 2 and 3, estimates of average F in the terminal year for ages 3-9 (Figure PC2), and catchability coefficients (spring and autumn surveys) for the survey indices relative to the VPA population size estimates (Figure PC3). The door conversion coefficients were applied to the pre-1985 data (collected using the BMV doors).

Increasing the door coefficient had the effect of reducing stock size estimates relative to the base run for the more recent years in the time series, e.g., for age 2 applying a door conversion coefficient of 1.5 depressed the 1989 stock size estimate from 28 million to 22 million fish, a reduction of over 20%. For ages 2 and 3 the effects of the coefficient appeared imperceptible prior to the third year (backward in the time series). At the same time un-weighted average F values (for ages 3-9) for the terminal year increased from approximately 0.3 to 0.4, an increase of about 25%.

Incorporating commercial indices had the effect of depressing stock size estimates still further, e.g., from 28 million to 14 million fish at age 2, while terminal year F increased substantially across the range of door conversion coefficient values tested. However, note that the influence of commercial CPUE data should not be taken as a general conclusion but specific to this example. It does illustrate how sensitive assessment results may be to the use of various data sources. The effect on F was proportionally less as the door conversion coefficient was increased, however. Some concern was expressed that since CPUE indices were not independent of catch at age a confounding effect might result from using them. Catchability was increased throughout the time series as the conversion coefficient increased for both the spring and autumn survey time series, with effects being minimal in the year in which the door change was made (1985).

Plenary Conclusion

The Plenary concluded that in cases where experiments have indicated an effect of vessel or door changes, the sensitivity of the assessment results to assumption about survey efficiency should be explored quantitatively. In practice this means presenting analyses which use corrected and uncorrected survey data until a clear judgement can be made as to which analysis is most appropriate.

It was noted that for any given situation effects would vary depending upon the time series and indices available. As a rule, however, the effect of using such coefficients would be to make assessment conclusions more conservative given the greater fishing power of the polyvalent doors in relation to the historical BMV time series. This effect will be particularly important for stock size projections due to their dependence on events in the terminal year. The importance of testing for differences in fishing power in relation to size class was also noted given the obvious potential impact of applying a conversion coefficient on recruitment estimates.

Table PC1.

Number non-zero pairs, p values ($Pr > | T |$ under Ho: no difference between vessels), conversion coefficients and approximate 95% confidence intervals for NEFC vessel fishing power study. Data are pooled across years; 510 total tows

Species	Number non-zero tows		p values		VCF_{number} [a]	Approx. 95% Confidence Interval	VCF_{weight}	Approx. 95% Confidence Interval
	number	weight	number	weight		number		weight
Alewife	25	24	0.273	0.034			0.58	0.39 - 0.99
American Plaice	79	78	0.017	0.001	0.82	0.70 - 0.94	0.69	0.56 - 0.85
Anchovy uncl.	21	17	0.401	0.086				
Atlantic Cod	121	121	0.003	0.001	0.79	0.69 - 0.94	0.67	0.53 - 0.87
Atlantic Herring	53	52	0.002	0.000	0.59	0.41 - 0.80	0.54	0.39 - 0.71
Atlantic Mackerel	15	15	0.586	0.854				
Black Sea Bass	22	14	0.350	0.888				
Bluefish	50	44	0.496	0.362				
Butterfish	252	212	0.067	0.057				
Cunner	15	15	0.009	0.013	0.56	0.42 - 0.85	0.51	0.32 - 0.81
Cusk	15	15	0.005	0.397	0.66	0.52 - 0.82		
Fawn Cusk - Eel	33	32	0.048	0.144	0.63	0.45 - 1.05		
Fourbeard Rockling	18	11	0.242	0.125				
Fourspot Flounder	166	161	0.010	0.005	0.85	0.76 - 0.96	0.84	0.75 - 0.95
Goosefish	60	60	0.034	0.102	0.83	0.68 - 1.00		
Gulfstream Flounder	57	29	0.001	0.003	0.70	0.56 - 0.84	0.60	0.47 - 0.80
Haddock	117	113	0.013	0.005	0.82	0.69 - 0.95	0.79	0.67 - 0.92
Little Skate	197	195	0.002	0.002	0.83	0.74 - 0.94	0.81	0.72 - 0.94
Longhorn Sculpin	153	150	0.005	0.000	0.82	0.72 - 0.95	0.77	0.68 - 0.87
Mailed Sculpin	28	15	0.842	0.038			1.67	0.94 - 2.67
Northern Searobin	61	56	0.836	0.715				
Ocean Pout	57	56	0.004	0.004	0.70	0.55 - 0.88	0.69	0.55 - 0.89
Pollock	32	32	0.917	0.658				
Red Hake	160	153	0.060	0.013			0.79	0.65 - 0.91
Redfish	42	40	0.200	0.056				
Round Herring	18	11	0.971	0.735				
Sand Lance	40	16	0.017	0.785	0.50	0.29 - 0.77		
Scup	83	71	0.436	0.233				
Sea Raven	101	95	0.757	0.483				
Silver Hake	327	293	0.470	0.616				
Smooth Dogfish	37	37	0.117	0.091				
Spiny Dogfish	192	192	0.000	0.003	0.79	0.69 - 0.90	0.81	0.70 - 0.92
Spotted Hake	70	70	0.527	0.475				
Summer Flounder	66	66	0.208	0.152				
Thorny Skate	64	59	0.347	0.770				
White Hake	98	98	0.130	0.428				
Windowpane	144	140	0.003	0.004	0.82	0.73 - 0.93	0.80	0.69 - 0.92
Winter Flounder	128	127	0.996	0.467				
Winter Skate	147	147	0.028	0.003	0.82	0.66 - 0.97	0.74	0.63 - 0.90
Witch Flounder	29	29	0.857	0.795				
Yellowtail Flounder	117	115	0.011	0.041	0.85	0.77 - 0.96	0.85	0.74 - 0.96
American Lobster	123	120	0.350	0.334				
Horseshoe Crab	16	15	0.011	0.029	1.66	1.25 - 2.42	1.91	1.14 - 3.55
Jonah Crab	20	19	0.003	0.003	0.34	0.19 - 0.56	0.31	0.18 - 0.61
Lady Crab	42	33	0.660	0.687				
Longfin Squid	261	251	0.039	0.033	0.83	0.71 - 1.03	0.85	0.74 - 0.99
Rock Crab	55	44	0.000	0.150	0.58	0.40 - 0.71		
Sea Scallop	86	70	0.052	0.395	1.22	0.99 - 1.45		
Shortfin Squid	230	207	0.000	0.000	0.64	0.54 - 0.77	0.71	0.59 - 0.87
Shrimp uncl.		36		0.469				
All Species Combined	510	510	0.000	0.000	0.85	0.78 - 0.94	0.80	0.75 - 0.86

[a] VCF-Vessel Conversion Coefficient (applied to DELAWARE catch)

Table PC2.

Number non-zero pairs, p values ($Pr > | T |$ under Ho: no difference between doors), conversion coefficients and approximate 95% confidence intervals for NEFC door fishing power study. Data are pooled across years; 345 total tows

Species	Number non-zero tows		p values		DCF_{number} [a]	Approx. 95% Confidence Interval	DCF_{weight}	Approx. 95% Confidence Interval
	number	weight	number	weight		number		weight
Alewife	44	39	0.402	0.666				
Alligatorfish	16		0.902					
American Plaice	110	106	0.427	0.714				
American Shad	15		0.511					
Atlantic Cod	107	107	0.000	0.000	1.56	1.33 - 1.88	1.62	1.37 - 1.94
Atlantic Herring	49	47	0.265	0.203				
Black Sea Bass	25	22	0.579	0.603				
Blueback Herring	29	26	0.537	0.822				
Butterfish	69	67	0.871	0.866				
Fourbeard Rockling	55	50	0.903	0.708				
Fourspot Flounder	119	118	0.095	0.200				
Goosefish	30	30	0.587	0.835				
Gulfstream Flounder	28	15	0.039	0.446	0.66	0.46 - 0.94		
Haddock	109	109	0.000	0.000	1.49	1.18 - 1.82	1.51	1.22 - 1.85
Little Skate	132	131	0.016	0.012	1.20	1.04 - 1.42	1.22	1.06 - 1.43
Longhorn Sculpin	132	130	0.000	0.000	1.44	1.20 - 1.67	1.39	1.11 - 1.67
Mailed Sculpin	30		0.019		1.67	1.09 - 2.37		
Northern Searobin	55	53	0.100	0.122				
Ocean Pout	77	74	0.916	0.809				
Pollock	19	19	0.027	0.009	2.21	1.11 - 4.30	2.90	1.38 - 5.54
Red Hake	136	134	0.001	0.005	1.31	1.11 - 1.54	1.26	1.06 - 1.45
Redfish	46	45	0.683	0.469				
Sea Raven	67	66	0.648	0.163				
Silver Hake	182	163	0.612	0.971				
Smooth Skate	31	29	0.003	0.024	1.65	1.23 - 2.14	1.70	1.07 - 2.66
Spiny Dogfish	120	120	0.579	0.679				
Spotted Hake	17	16	0.465	0.676				
Summer Flounder	50	50	0.537	0.369				
Thorny Skate	114	110	0.296	0.121				
White Hake	71	71	0.205	0.296				
Windowpane	25	22	0.001	0.001	1.54	1.28 - 1.94	1.67	1.34 - 2.18
Winter Flounder	60	60	0.000	0.004	1.46	1.21 - 1.85	1.39	1.15 - 1.72
Winter Skate	92	92	0.062	0.011			1.36	1.05 - 1.70
Witch Flounder	31	31	0.079	0.248				
Yellowtail Flounder	81	79	0.016	0.006	1.22	1.02 - 1.39	1.28	1.07 - 1.46
American Lobster	97	97	0.174	0.821				
Jonah Crab	25	19	0.222	0.074				
Longfin Squid	115	114	0.085	0.016			1.24	1.07 - 1.47
Octopus uncl.	18		0.577					
Sea Scallop	83	73	0.008	0.176	1.39	1.15 - 1.79		
Shortfin Squid	69	58	0.469	0.195				
Shrimp uncl.		52		0.057				
ALL SPECIES COMBINED	345	345	0.000	0.000	1.27	1.17 - 1.38	1.40	1.26 - 1.52

[a] DCF-Door Conversion Coefficient (applied to BMV catch)

EFFECTS OF DOOR CONVERSION COEFFICIENT ON STOCK SIZE (AGE 3)

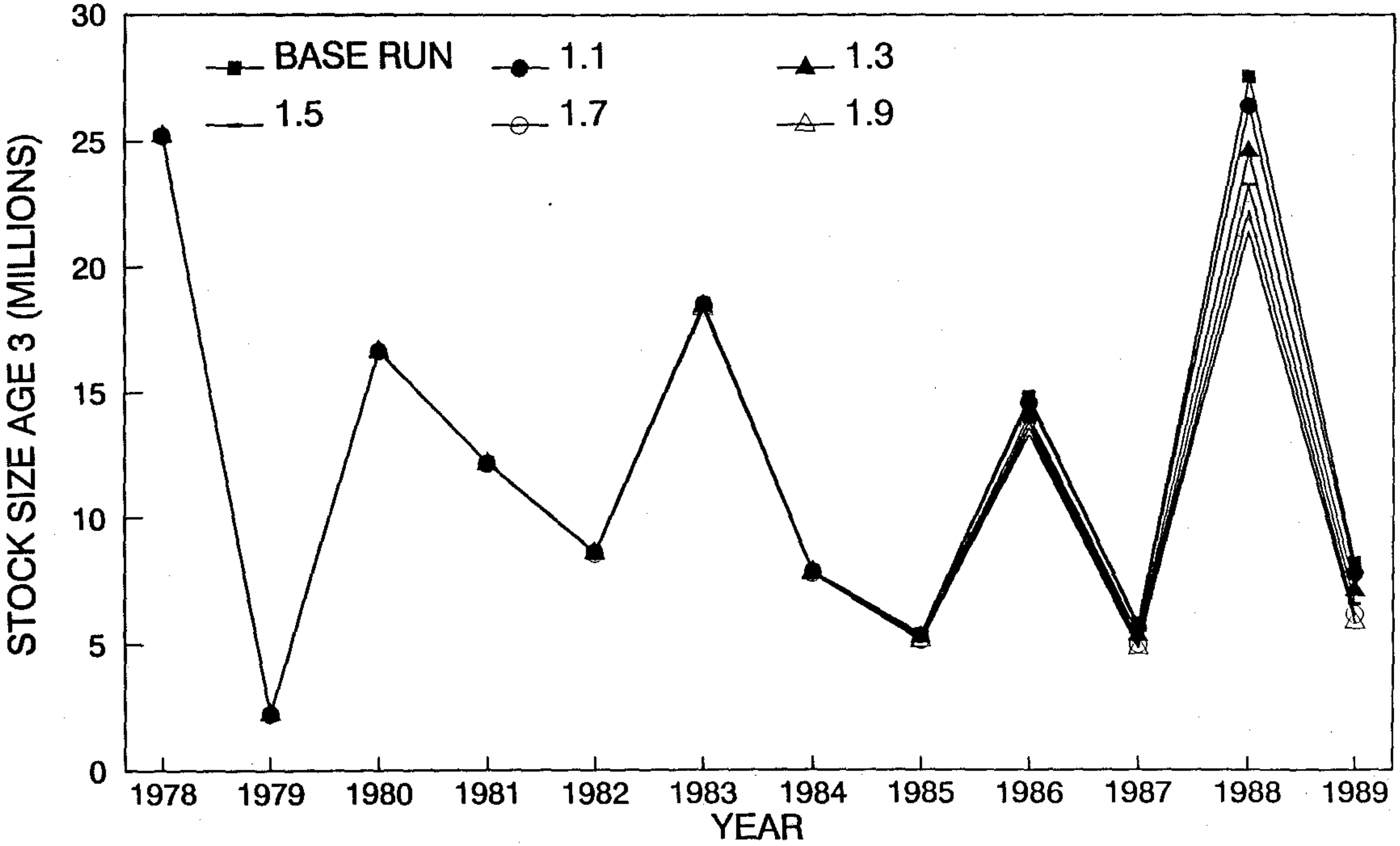


Figure PC1.

EFFECTS OF DOOR CONVERSION ON AVERAGE F IN TERMINAL YEAR

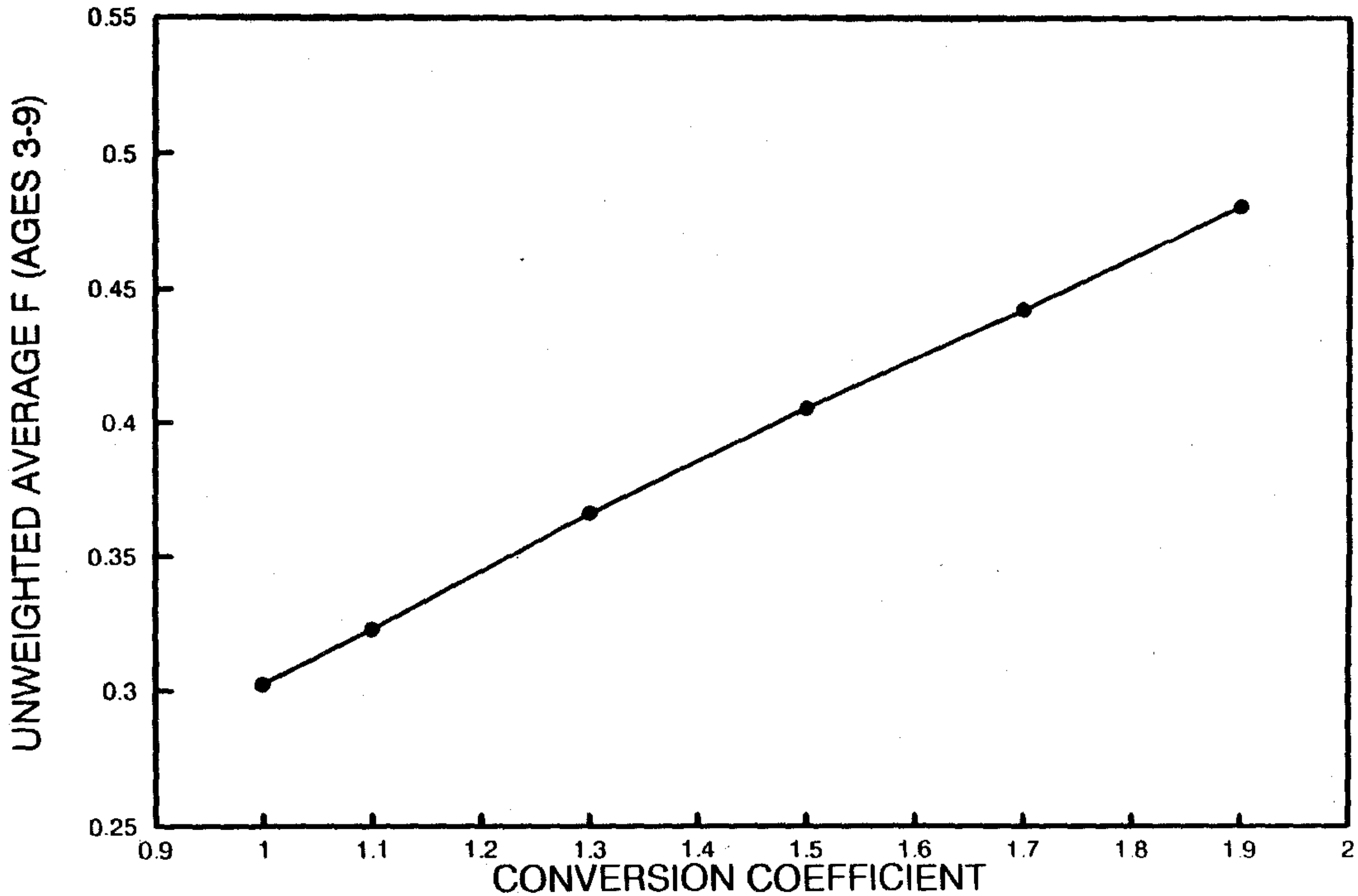


Figure PC2.

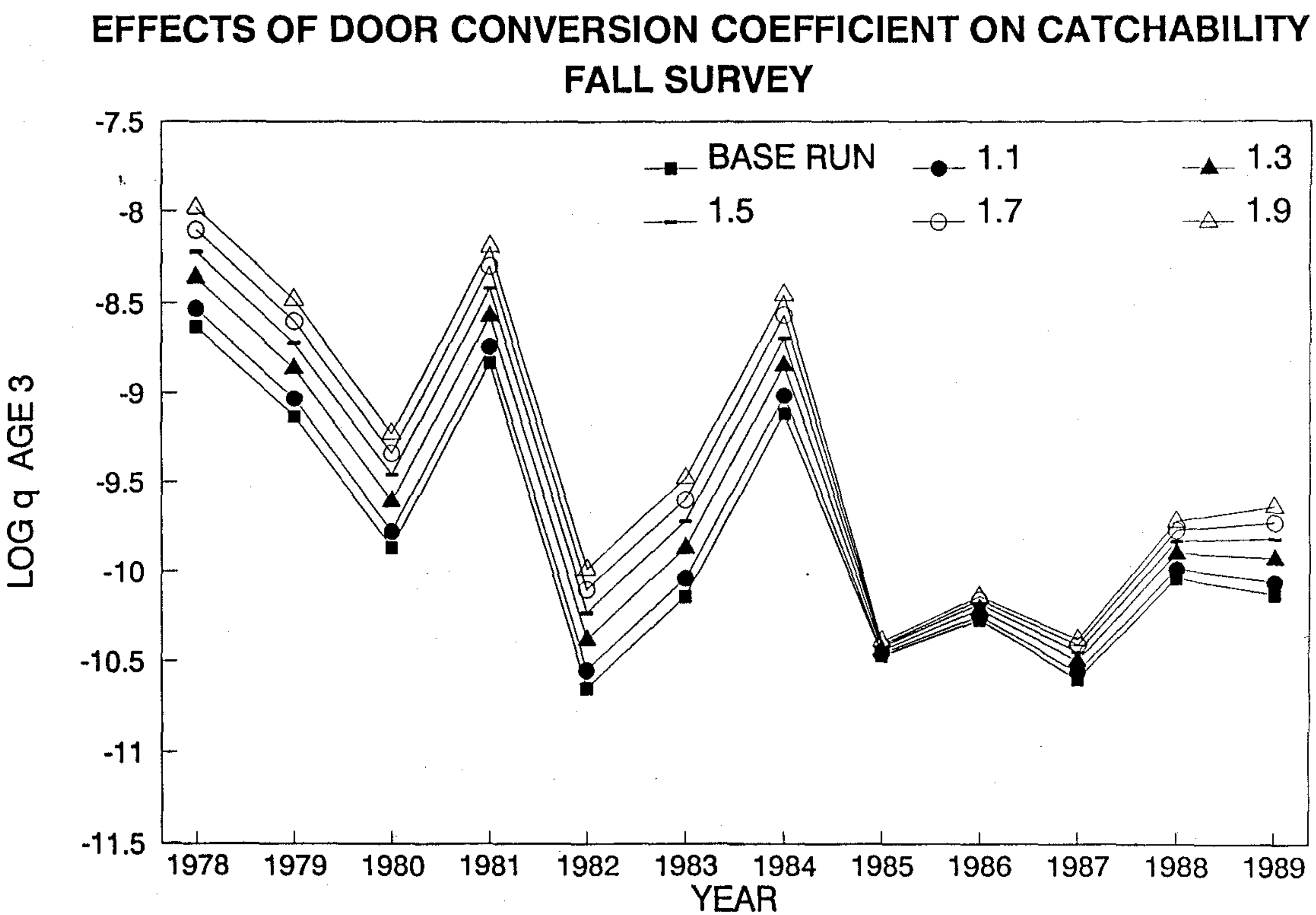

EFFECTS OF DOOR CONVERSION COEFFICIENT ON CATCHABILITY
FALL SURVEY
BASE RUN
1.1
1.3
1.5
1.7
1.9
-7.5
-8
-8.5
-9
-9.5
-10
-10.5
-11
-11.5
LOG q AGE 3
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
YEAR

Figure PC3.

LOBSTER WORKING GROUP REPORT

The members of this working group are listed in Table PD1. Josef Idoine (NEFC) and Bruce Estrella (MA DMF) are Co-Chairmen.

Joseph Idoine presented the **Minutes of Lobster Scientific Working Group** (SAW/12/Pl/9) which met during 10 - 11 October 1990. In part, the meeting was held in response to the terms of reference developed at SAW-10, where a Lobster Assessment Working Group was formed to :

1. Investigate the feasibility of a combined inshore/offshore lobster assessment.

2. Develop a list of data requirements and collection techniques for lobster assessment.

3. Evaluate the available information on migration patterns of lobsters (relative to item 1 above).

Feasibility of a Combined Inshore/Offshore Lobster Assessment

Given the lack of resources and fundamental knowledge, the group determined that a combined inshore/offshore assessment would not be possible at this time. The group does, however, suggest that a region-wide study could provide insight to such questions as: What is the relationship between inshore and offshore lobster? Is there spawning or settlement offshore? and, What is the difference between an inshore and offshore lobster?

Proposed was implementation of a coastwide cooperative venture across all jurisdictions with the intent to determine where eggs are hatched and at what rate lobsters migrate. The major objective would be to model movement, growth (molt probability), exploitation rate, mortality, spawning area gradients, size at maturity, fecundity, sex ratio, and population size. As the problem of regional variation in growth rates complicates uniform assessments, this must be overcome and to facilitate grouping prior to assessment regional zones of common characteristics should be designated.

The need to generate new offshore tagging studies was expressed. The rationale for this being that changes in environmental conditions may produce different results from those obtained by Cooper and Uzmann about 20 years ago. Current knowledge of offshore lobster growth and mortality is derived solely from the results based on that work.

A consensus of the working group was that uniform, coordinated research efforts should be initiated in each respective state and offshore. Although the collection of lobster data through logbooks, prot sampling, and research trawl surveys was discussed along with the advantages and disadvantages of each, it was concluded that the existing "common denominator" is commercial lobster sea sampling. Sea sampling information is now gathered in Massachusetts, New York, Maine, and Connecticut and commercial sea sampling programs are to be launched by New Hampshire and Rhode Island in 1991. The need for enhanced offshore effort by NMFS which has the historical responsibility for collecting data offshore, and the possibility of a cooperative state-federal effort was discussed.

Discussed also was the region-wide standardization of sampling with respect to randomization of habitat and seasonal differences and representation of major fishing areas. The availability of Coast Guard gear location maps was proposed as a means of determining the area of traditional offshore lobstering grounds which would facilitate the development of an appropriate sampling design. Assistance from the Atlantic Offshore Lobstermen's Association (an estimated 66 boats) may also be available in this regard.

As data gathering options, the availability of personal fishing records or the implementation of a log book program was discussed.

Current Data Collection Methods

Various state data collection methods were discussed. Long-term sampling programs designed to provide CPUE and biological data for regular assessments of the resource were determined to be:

ME	port sampling + sea sampling
NH	catch reports (diving + sea sampling planned)
MA	catch report + sea sampling
RI	(sea sampling planned)
CT	logbooks
NY	sea sampling
Canada	Logbooks are mandatory for offshore fishery and a limited number are also distributed to inshore fishermen on a voluntary basis. The Canadian representative stressed the importance of two-way communication with fishermen who provide data.

Assessment Data Needs

The following assessment data needs were defined:

Growth rate via tagging data - regional differences (NY, ME, MA)

Molt probability

Mortality

Maturity - merits and concerns about cement gland staging

Proportion ovigerous

Fecundity

Sex ratio (differences regionally and by habitat type)

Sex differences in of the above

Expressed was the need to develop a unified data base of these data which would be provided by all working group members. Data could be stored by NMFS for final coast wide assessments.

Mitigation Patterns

A discussion of summary results of various lobster tagging studies, with specific reference to migration (Table PD2) revealed that although qualitative information on seasonal, directional and size specific movement is known, information on rate of movement was lacking. It was noted, however, that the effects of lobster immigration and emigration was important when considering estimates of mortalities, especially on the regional basis.

Most tagging studies have shown some small percentage of returns to exhibit long distance movement depending upon the size and condition of tagged lobster. If this occurs coastwide, it may not necessarily represent permanent net loss to the inshore resource. Recent tagging studies in the Gulf of Maine (Canada to Massachusetts) reveal evidence for a homing tendency (circular movement) and numerous studies indicate that a seasonal offshore-inshore-offshore movement pattern occurs annually. Further studies may shed light on such questions as, Does the inshore resource ever really lose biomass through sources other than fishing or natural mortality? and Is there equilibrium resulting from the immigration of offshore lobster? as well as other questions related to movement.

While the Working Group did not consider a resource-wide assessment to be feasible at this time, it did consider the possibility of combining, on a regular basis, a joint document that would include current status reports and updates of progress made in lobster assessment methodology. The feasibility of such a joint inshore-offshore report was viewed favorably and a target date of 1991 was tentatively established. Potential topics for compilation of each state's data include, CPUE, mortality, and size composition by sea sampling, port sampling, or research trawling.

In addition, region-wide workshops on molt staging, migration studies, maturity, fecundity, growth, mortality, and CPUE analytical techniques were considered to be useful. These would help to refine techniques and standardize research. Participation of representatives from academia and management in future meetings was discussed.

Plenary Conclusion

As the Plenary concluded that activities of this Working Group should best continue under the aegis of the ASMFC Technical Group, a report on this topic will not be presented at the next SAW.

Table PD1. Lobster Working Group Participants

NAME	AFFILIATION
Thomas E. Angell	Rhode Island Department of Environmental Management, Division of Fish and Wildlife
Mark Blake	Connecticut Department of Environmental Protection
David Borden	Rhode Island Department of Environmental Management
Philip T. Briggs	New York State Department of Environmental
Steve Cadrin	Massachusetts Division of Marine Fisheries
Peter Colosi	National marine Fisheries Service, Regional Office, Gloucester
Bruce T. Estrella	Massachusetts Division of Marine Fisheries
Michael J. Fogarty	National Marine Fisheries Service, Northeast Fisheries Center
Karen Graulich	New York State Department of Environmental
Douglas Grout	New Hampshire Fish and Game Department
Josef S. Idoine	National Marine Fisheries Service, Northeast Fisheries Center
Jay S. Krouse	Maine Division of Marine Resources
Glenn Nutting	Maine Division of Marine Resources
Gary Robinson	Main Division of Marine Resources
Douglas Pezzack	Department of Fisheries and Oceans, Canada

Table PD2. Lobster Migration Studies

Maine:	Movement of lobster which were as large as the first recruit molt group was minimal; a large percentage moved 1-2 mi. and some moved 3-4 miles, only a few moved up to 10 mi.
New Hampshire:	There was some movement of small lobster reported in estuaries and CPUE changes were observed in high density areas seasonally.
Massachusetts:	Minimal movement was observed in inshore fisheries north and south of Cape Cod including small yet mature Buzzards Bay lobster, many of which were ovigerous. There was net easterly movement through the Cape Cod Canal and northward along the western shore of Cape Cod Bay. Lobsters tagged south of the Elizabeth Islands moved primarily south and southwest. Lobster tagged in Cape Cod Bay exhibited minimal movement. In contrast extensive migratory behavior was observed along outer Cape Cod. It is generally accepted that this region hosts a primarily offshore group of lobsters which moves shoalward each spring and summer, then northward along the arm of Cape Cod into Cape Cod Bay and other northern inshore coastal regions. Returns have been reported from Cape Cod Bay, Boston Harbor, Cape Ann, Massachusetts and Cape Elizabeth, Maine. A high percentage of the lobster in the outer Cape Cod region are large V-notched females which were notched presumably off the coast of Maine.
Connecticut:	Several small but mature lobster were recovered in offshore canyons.
New York:	Most lobster which were at large > 1 yr were recovered from the general release area.
Canada:	Little movement of juveniles in Canada, but movement is pronounced (in mature sizes) in northern Gulf of Maine area offshore.

SQUID WORKING GROUP REPORT

Members: T. Hoff, Chair and C. Heaton (MAFMC); H. Russell (NEFMC) J. Brodziak, R. Schultz, and A. Rosenberg (NEFC), P. Jones, M. Rayzin, and R. Ross (NERO); D. McKiernan (MA DMF).

The Working Group met in May 1991 to address the following terms of reference established at the Tenth SAW:

1. Evaluate Falklands experience with squid relative to daily reporting requirements of fleets and usefulness of data in population estimates.

2. Look at historical CPE data and then propose appropriate comparisons of population estimates derived from fishing fleet data with NEFC survey abundance indices.

3. Select components of fleets (i.e., inshore Mass fishery or freezer trawlers segments of fleet) for data reporting.

4. Suggest to MAFMC and RO that changes in reporting accompany quota setting process.

The Working Group Report, **Research Evaluation of Reporting Requirements for Various Fleet Components of Squid Fisheries** (SAW/12/PL/8) was presented by Dr. Jon Brodziak.

Term of Reference #1

The world squid market appears to be dominated by the fisheries in the Falkland Islands and New Zealand. The assessment methodology and management system used in the Falklands involves the Leslie-Delury analysis which requires accurate daily catch information from a key segment of the fleet, and weekly or monthly catch data from the remainder of the fleet. It was postulated that the Falkland system could be germane for Illex and Loligo fisheries of the northwest Atlantic.

Terms of Reference #2 and #3

Dr. Brodziak examined the recent trends in the domestic Loligo fishery, by looking at the possibility of predicting an index of relative Loligo abundance, and by applying a retrospective Leslie-Delury analysis to estimate weekly catch and population size for area 538 of the Loligo fishery in 1990.

CPUE in the domestic fishery for Loligo was found to have changed over the past decade as directed foreign fishing ceased. Domestic CPUE increased in areas 61 and 62 in recent years (Figure PE1, Brodziak 1991), while CPUE has remained relatively steady in area 53 and fluctuated in areas 51, 52, and 63. An examination of average CPUE, where CPUE is averaged over all trips landing Loligo, shows a similar pattern. Loligo has also been retained as a higher percentage of total landed weight in trips that land them within areas 61 and 62 during the late 1980s (Figure PE2). Overall, the increase in CPUE in areas 61 and 62, a recent increase in the number of directed trips, and a higher landings ratio in areas 61 and 62 may indicate a shift in fishing effort from other species to Loligo in the Mid-Atlantic region.

The possibility of predicting future Loligo abundance using NEFC fall survey indices was examined, under the assumption that, in any given year, the abundance of the fishable Loligo population is related to the value of the fall recruit index (stratified mean number per tow of individuals with dorsal mantle length > 8 cm). For the period 1982 - 1990, the Loligo recruit index and the directed CPUE index have been moderately correlated ($r = 0.514$). Time series methods were applied to the recruit index series for 1967 - 1990 to develop a predictive model for this index of Loligo abundance. An ARIMA (2,1,0) model provided the best fit for the long-transformed recruit series. Model parameters were estimated using the recruit series from 1967 - 1988 and 1967 - 1989 to provide in-sample forecasts of the 1989 and 1990 recruit indices, respectively, for comparison with their observed values. Model parameters were then re-estimated using the recruit series from 1967 - 1990 to provide an out-of-sample forecast for 1991. The relative accuracy of the in-sample forecast results suggest that the development of predictive models for relative Loligo abundance should be possible.

Leslie-Delury analyses (Rosenberg, et al, 1990) were applied to the area 538 Loligo fishery in 1990 to examine whether data presently available could be used to produce accurate weekly estimates of catch and population size. Weekly length frequency data obtained from Massachusetts state sampling programs during May and monthly length frequency data obtained from NMFS weight-out sampling during June were applied to commercial landings to produce weekly CPUE in numbers of squid. Some assumptions and results of these analyses are shown in Figures PE3 and PE4, respectively. Modification of the basic model to include squid migration, spawning mortality, and a length-based separation of cohorts, as well as continued weekly length frequency sampling and expanded sampling coverage of the fishing fleet, are critical elements for improving the accuracy of weekly catch and population size estimates for this fishery.

Term of Reference #4

This Term of Reference is not limited to the problem of what data are necessary to develop the capability for modelling the Falkland fishery in that it also deals with the changes relative to a quota setting process. Significant amounts of market and other economic information are required for decision making in this regard. Timely availability of this information is of critical importance since currently actions taken in one year are often based on information that is more than one year old.

To develop a true picture of conditions, management usually requires information from a combination of sources, in addition to the bimonthly landing reports which the NMFS Regional Office distributes. Although the Working Group considers that it is critical to know what timely biological input/economic tools and data sets could be used to better track the industry, imposition of logbooks at this time was considered to be unjustified.

In an attempt to institutionalize the economic and marketing information available, the Working Group categorized information into three groups: rapid, intermediate, and longer-term sources. It was the consensus of the group that a general picture of current US supply and market conditions could be developed within a few days after use of the first two sources of data. A more comprehensive analysis will, however, be required to develop an accurate picture of international conditions and forces which shape the US markets in the near future.

The group extensively discussed the Massachusetts inshore (strata 58) squid fishery, as the Mass. division of Marine Fisheries is expending significant effort to sample this fishery. Although concern was expressed that the inherent variability in the catches among years may be too large for fine-level management of the resource in only part of its range, it was considered that the Mass. efforts of sea sampling on a weekly basis from 15 April through 15 June, their daily reporting requirements, and their collection of length frequency data is important and should be continued until their usefulness is in the Delury model is fully evaluated.

Attempts to flush out the complete intelligence network yielded very little additional information that could be readily and efficiently available for decision making. Although it is possible that the anecdotal "Port Highlights" may provide some miscellaneous information, the problem of confidentiality may be overwhelming. Effort (number of trips and number of boats) at the port level appears to be the only new information that could be incorporated into the bimonthly RO report without destroying the current port agent/weighout system. Efficient and timely generation of total landings of Loligo and Illex, by vessel class, on trips where squid is at least 50% (directed) or the effort (number of trips) by vessel class does not seem possible. Under the present system, effort and landings by class are not available until at least 60 - 90 days after collection.

Working Group Recommendations

1. Strongly encourage Massachusetts to continue the collection of length frequency data since these are the only length data collected at present.

2. Evaluate recommendation 1 for its usefulness in the assessment methodology being developed in Terms of Reference 2 and 3.

3. Some sea sampling effort should be extended toward freezer trawlers.

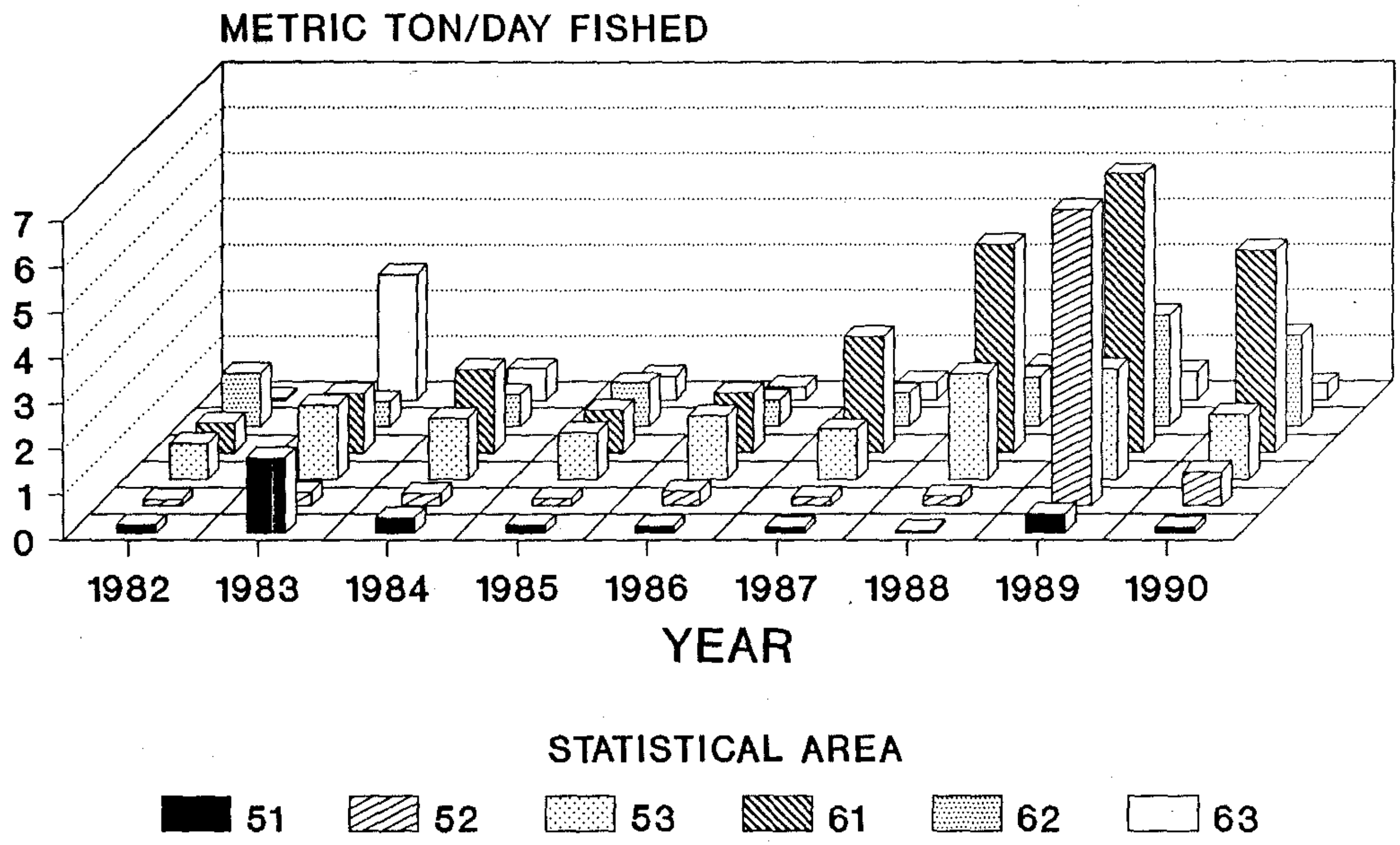
4. Data from some internal joint ventures appear not to have been provided to NMFS, a protocol for routine submission needs to be adopted for inclusion of all these data.

5. Support SARC recommendations that deal with Terms of Reference 2 and 3.

6. Provide effort (number of trips and number of boats data with bimonthly RO reports.

Plenary Conclusion

The Plenary concluded that sampling conducted by Massachusetts in the Vineyard Sound is indeed important and should continue as the Working Group recommended and that the usefulness of these data in the Delury model be evaluated. The participants also emphasized the importance of the recommended additional sampling of freezer trawlers on the basis that such information is critical in a quota system.



EXCLUDES TRIPS TO AREA 56
CPUE IS TOTAL LANDINGS
DIVIDED BY TOTAL DAYS FISHED

Figure PE1. Domestic CPUE, 1982 - 1990.

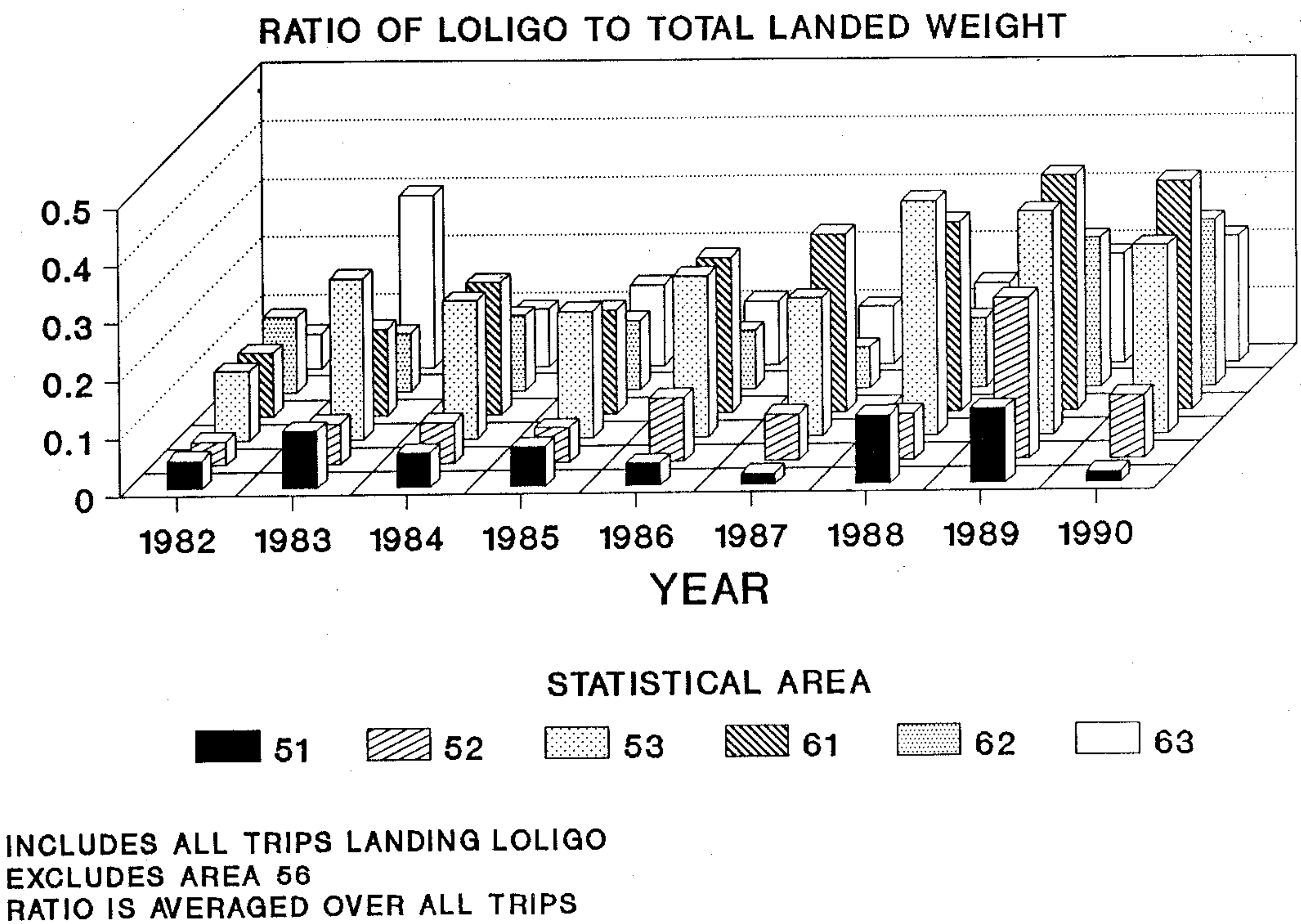
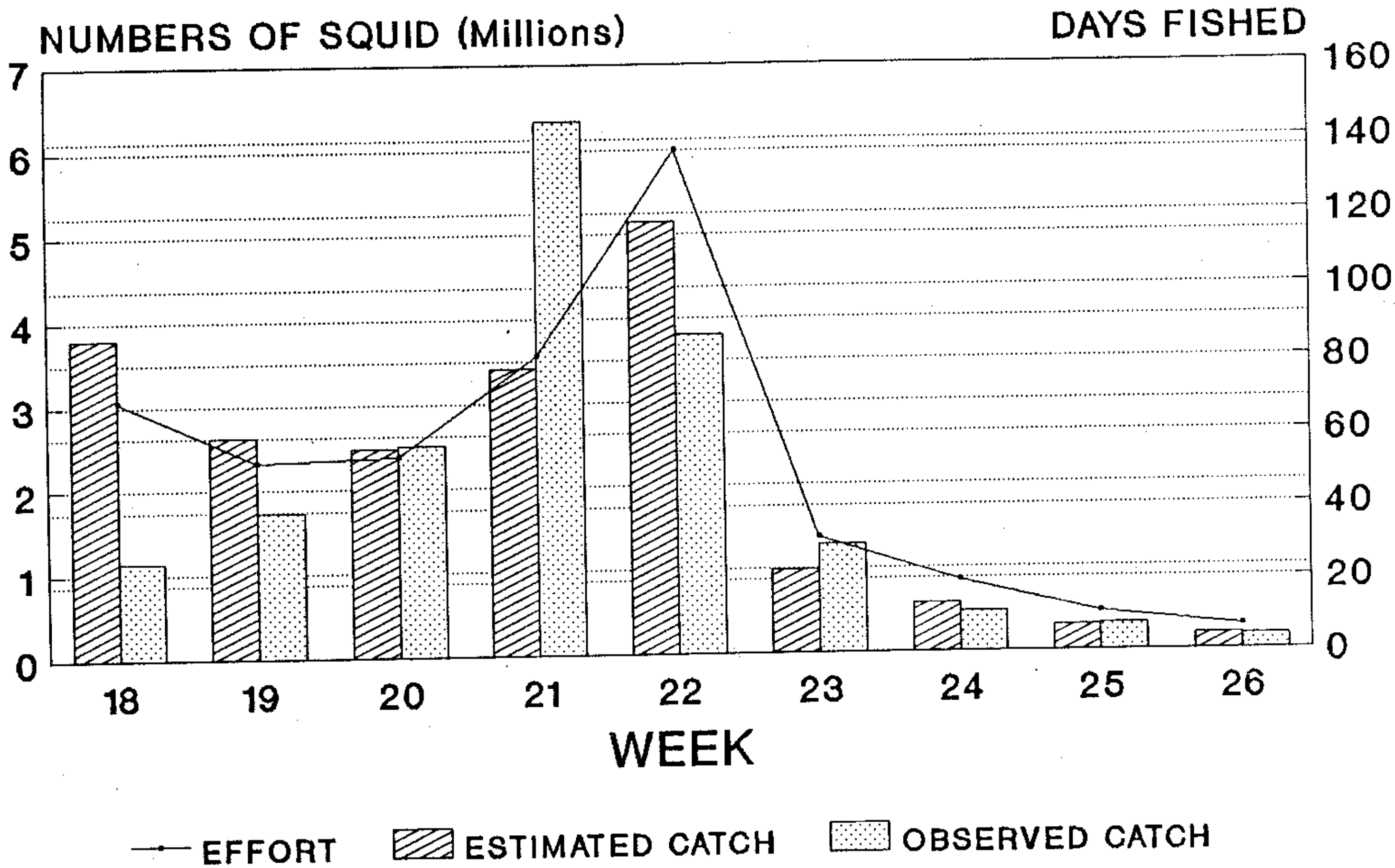


Figure PE2. Total landad weight by statistical area, 1982 - 1990.

- NATURAL MORTALITY IS CONSTANT
- THERE IS NO IMMIGRATION OR EMIGRATION OF SQUID
- ONE CAN ESTIMATE CATCHABILITY AND INITIAL POPULATION SIZE USING LINEAR REGRESSION OF OBSERVED CPUE ON ACCUMLATED CATCH
- FISHING FLEET IS HOMOGENEOUS WITH RESPECT TO CATCHABILITY COEFFICENT
- IT SUFFICES TO CONSIDER WEEKS 18 THROUGH 26 (BEGINNING OF MAY TO THE END OF JUNE)
- CATCH (BY WEEK) = CATCHABILITY * EFFORT * POPULATION SIZE

Figure PE3. Some assumptions of analyses.



MODEL FITTED TO ENTIRE FLEET
WEEKLY NATURAL MORTALITY IS M=0.0225
MSE = 18.35 trillion

Figure PE4. Some results of analyses.

THIRTEENTH SAW TERMS OF REFERENCE AND TIMING

A list of potential topics for review by the Stock Assessment Review Committee (SARC) and topics to be presented at the Plenary were developed by the participants for the consideration of the SAW Steering Committee.

Suggested Species/Stocks to Review

Participants identified the following stocks for review at the next session of the Stock Assessment Review Committee:

- Sea herring

- Porpoise by-catch

  Review of by-catch estimation procedures at the next SAW was recommended at a recent peer review of the NEFC Marine Mammals Investigation.

- Summer flounder

  An updated assessment by the Summer Flounder Working Group is of interest to the MAFMC.

- Scup

- Black sea bass

- Winter flounder

  A review of work to date would be useful to the Environmental Council in December. It was noted that Connecticut work on the species could be requested to be reviewed.

- Cod (Georges Bank)

- Scallops (Georges Bank)

  It was suggested that the Sea Scallop Working Group perform this analysis.

- Haddock

Priority to review these stocks should be based on management consideration.

Special Topics and Working Group Presentations

- Sea Sampling Analysis Working Group (WG #28)

  Report should address the new terms of reference (see section on Sea

Sampling Analysis Working Group).

- o Adequacy of Biological Sampling Working Group (WG #31)
  The Plenary concluded that there is a need to establish this working group to address the adequacy of biological sampling from a number of sources, including sea sampling, port sampling, surveys, and Marine Recreational Fisheries Sampling Survey (MRFSS).

- o Recreational Fisheries Statistics Working Group (WG #32)
  The Plenary concluded that data format, accessibility, limitations, and problems associated with the application of these data should be examined. Paul Perra (ASMFC) was suggested to Chair the group and Tom Morrissey (NEFC) would assist in coordination among the various organizations and the Northeast Fisheries Center.

- o Data Access
  The topic should include an overview of the NEMFIS (NE Marine Fisheries Information System) and updates of NMFS NE Regional Office, Councils, and ASMFC systems, noting any redundancy among these. Although some would establish a working group on this topic, it was concluded not to do so but only revisit the topic at the next SAW as the NEFC data group is just being reorganized. Before terms of reference for a working group on the topic are established, it will be necessary to sort out the NEFC internal software problems from regional ones, as well as the role of the "Regional Data Base Manager."

Timing

Barring conflicts with meetings already planned, it was recommended to hold the next SARC meeting during the first week of December 1991 and the Plenary, 7 - 9 January 1992. Participants were disappointed that some members of the SAW Steering Committee did not attend the SAW-12 Plenary and noted that the Committee and other managers should be encouraged to attend future sessions.

Other Business

The issue of SAW documentation was discussed. It was concluded that a SAW Research Document Series will be established. SAW working papers will thus be modified according to the recommendations of the SARC review or suggestions of the Plenary. For the time being, the SAW report will remain in the NEFC Reference Series and draft reports from the two sessions will be available for the participants as soon as possible.

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STOCK ASSESSMENT REVIEW COMMITTEE

CONSENSUS SUMMARY OF ASSESSMENTS

INTRODUCTION

The Stock Assessment Review Committee (SARC) of the 12th Regional Stock Assessment Workshop (SAW) met at the Northeast Fisheries Center, Woods Hole, June 3 - 8, 1991. The eleven member Committee (Table S1) reviewed analyses for eight species/stocks of animals (Table S2) with distributions ranging from the Gulf of Maine through the Mid-Atlantic. In addition to the Committee, more than thirty other persons were in attendance, some participating in discussions and some running analyses that the SARC needed to have performed on site. Dr. John B. Pearce, NEFC Acting Science and Research Director and member of the SAW Steering Committee, welcomed the participants.

A total of thirteen papers (Table S3) were presented by scientists involved in the work of these species/stocks. Presentations included full and revised assessments, applications of newly developed analytical methods, and the exploration of sampling data. The SARC technically evaluated all information presented and determined: (1) What is the best current assessment of the resource?; (2) What are the major sources of uncertainties in the assessment?; and (3) How might these uncertainties affect the picture of stock status? In some cases, the SARC considered it necessary to perform analyses in addition to those presented because of technical questions raised during discussion. These analyses were intended either to implement specific recommendations for improving the existing analyses or to explore sources and effects of uncertainties. In most cases, the Committee also ran catch projections. Recommendations for further work were made for each species.

The statements presented in this report are the consensus of the SARC. Appropriate tables and graphs have been attached to make the report self-contained. The report was presented at the 12th Regional Stock Assessment Workshop Plenary, 10 - 12 July, where the Advisory Report on Stock Status was prepared based on this report.

Table S1.

SAW-12 STOCK ASSESSMENT REVIEW COMMITTEE

Peter Colosi	Northeast Regional Office, NMFS
Ray Conser	Northeast Fisheries Center, NMFS
Michael Fogarty	Northeast Fisheries Center, NMFS
Tom Hoff	Mid Atlantic Fishery Management Council
Robert Kope	Southwest Fisheries Center, NMFS
Pamela Mace	New England Fishery Management Council
Ralph Mayo	Northeast Fisheries Center, NMFS
William Overholtz	Northeast Fisheries Center, NMFS
David Pierce	Atlantic States Marine Fisheries Commission/MA Department of Marine Fisheries
Andrew Rosenberg (Chair)	Northeast Fisheries Center, NMFS
Gerald Scott	Southeast Fisheries Center, NMFS

Table S2 12th NORTHEAST REGIONAL STOCK ASSESSMENT WORKSHOP
STOCK ASSESSMENT REVIEW COMMITTEE SESSION
NEFC Aquarium Conference Room
Woods Hole, MA
June 3 (9:00 a.m.) - June 8 1991
AGENDA

Monday, June 3

SPECIES/STOCK	SOURCE/PRESENTER(S)	RAPPORTEUR(S)
Atlantic mackerel	NEFC/W.Overholtz	R.Kope/R.Conser
Butterfish	NEFC/J.Brodziak	T.Hoff
Cod - Gulf of Maine	NEFC/F. Serchuk, R.Mayo, S.Wigley	P.Colosi A.Rosenberg

Tuesday, June 4

Yellowtail flounder - Georges Bank	NEFC/Yellowtail Flounder Working Group	M.Fogarty W.Overholtz
Southern New Eng.	" "	G.Scott/R.Mayo

Wednesday, June 5

<u>Illex</u> squid	NEFC/J.Brodziak	D.Pierce/T.Hoff
<u>Loligo</u> squid	NEFC/J.Brodziak	D.Pierce/T.Hoff

DISCUSSION AND REVIEW

Thursday, June 6

Sea scallops	WorkingGroup/ L.Goodreau	P.Mace A.Rosenberg

DISCUSSION AND REVIEW

Friday, June 7

DISCUSSION, REVIEW, AND REPORT PREPARATION

Saturday, June 8

REVIEW AND FINALIZE THE CONSENSUS SUMMARY OF ASSESSMENTS

Table S3.

SAW-12 SARC PAPERS

SAW/12/SARC/1	Stock Assessment of the Northwest Atlantic Mackerel Stock	W. Overholtz
SAW/12/SARC/2	Stock Assessment of Atlantic *Perprilus triacanthus*, in the Northwest Atlantic	J. Brodziak
SAW/12/SARC/3	Standardized CPUE Estimates for Gulf of Maine Cod Using the General Linear Model (GLM) Procedure	R. Mayo S. Wigley
SAW/12/SARC/4	Cod discards in the Gulf of Maine Fisheries: An Exploration of the Sea Sampling Data	S. Wigley
SAW/12/SARC/5	Revised Assessment of the Gulf of the Gulf of Maine Cod Stock	F. Serchuk R. Mayo S. Wigley
SAW/12/SARC/6	Stock Assessment of Short-finned Squid, *Illex illecebrosus*, in the Northwest Atlantic	J. Brodziak
SAW/12/SARC/8	Report of the Atlantic Sea Scallop Assessment Working Group: Preliminary Assessment Results	L. Goodreau
SAW/12/SARC/7	Stock Assessment of Long-finned *Loligo pealei*, in the Northwest Atlantic	J. Brodziak
SAW/12/SARC/9	A DeLury Model for Scallops Incorporating Length-Based Selectivity of the Recruitment to the Commercial Fishery	R. Conser

Table S3. Continued

SAW/12/SARC/10	Status of the Sea Scallop Fisheries Off the Northeastern United States, 1990	F. Serchuk S. Wigley
SAW/12/SARC/11	Length Composition Analysis of Atlantic Sea Scallop Using the MULTIFAN Method	M. Terceiro
SAW/12/SARC/12	An Assessment of the Southern New England and Georges Bank Yellowtail Flounder Stocks (Appendix 1, 2, 3, and 4)	R. Conser L. O'Brien W. Overholtz
SAW/12/SARC/13	Current Resource Conditions in USA Georges Bank and Mid-Atlantic Sea Scallop Populations: Results of the 1990 NEFC Sea Scallop Research Vessel Survey	S. Wigley

NORTHWEST ATLANTIC MACKEREL

The SARC reviewed the assessment of northwest Atlantic mackerel prepared by the Northeast Fisheries Center (SAW/12/SARC/1). Fishing mortality rates, year-class strength and partial recruitment vectors were estimated using Virtual Population Analysis (VPA) tuned to survey abundance indices by ADAPT (Gavaris, 1988; Conser and Powers, 1990). The analyses indicate that the stock has experienced several years of strong recruitment and very low fishing mortality rates resulting in a substantial increase in the point estimates of biomass in recent years. Variability in the estimates of the partial recruitment of younger age classes and the overall low level of fishing mortality rates on this stock result in coefficients of variation in the estimates of abundance at age of the order of 60%. It was the consensus of the SARC that the stock is currently under-exploited.

Background

For management purposes, the Atlantic mackerel (Scomber scombrus) fished in Northwest Atlantic Fisheries Organization (NAFO) subareas 2 through 6 are considered a unit stock. The fishery expanded from low levels in the early 1960s to peak landings of 436,609 MT in 1976, with the bulk of these landings attributed to countries other than the U.S. and Canada (Table SA1). Landings declined through the remainder of the 1970s coincident with a decline in stock biomass. Although at a low overall level, through the 1980s U.S. commercial landings have doubled from approximately 30 to 60 thousand MT, while recreational and Canadian catches have remained at relatively stable levels. Combined landings from all fisheries were projected to be 49,513 MT in 1990.

Data Sources

Landings data are available for the U.S. commercial and recreational fisheries, Canada, and other countries from NAFO subareas 2 through 6 since 1960 (Table SA1). Bycatch and discards are not perceived to be problems with the mackerel landings data. However, prior to 1978, U.S. recreational landings data were available only in 1960, 1965, 1970, and 1975. For assessment purposes, recreational landings in the intervening years were interpolated. Age composition data and mean weight at age are available since 1962 (Tables SA2 and SA3).

NEFC spring research surveys have indexed abundance since 1968 (Table SA4) and age composition of the survey abundance has been calculated as mean catch per tow for ages 1 through 14 (Table A5). Changes in survey gear during the time series considered were discussed by the SARC and were believed not to affect mackerel relative abundance indices. The natural mortality rate for mackerel was assumed to be 0.2.

Methodology

The northwest Atlantic stock was assessed using VPA of catch-at-age data from 1962 through 1990 tuned to survey abundance indices for ages 1 through 7 from 1970 through 1990 using ADAPT. Separable VPA (Pope and Shepherd 1982) was used to estimate the fishing mortality rate for age 1 mackerel in 1990.

Assessment Results

The assessment indicates that fishing mortality rates on fully recruited age classes have been relatively stable at low levels, on the order of 0.05, during the 1980s (Table SA6). Fishing mortality rates have declined during the last two years, falling to 0.02 in 1990. This is substantially lower than the fishing mortality rates estimated by the ADAPT analysis for the late 1960s and early 1970 which were generally on the order of 0.3 to 0.4, and are about $1/10^{th}$ of with updated estimates of $F_{0.1}$ (0.27) and F_{med}(0.25) current F is about $1/50^{th}$ of F_{max}(0.96).

The results of the separable VPA analysis of partial recruitment were judged to be poorer than those from ADAPT. The separable model assumes constant selectivity over time which is inappropriate for this stock. Therefore, the SARC agreed that the ADAPT results on partial recruitment are the best available.

Recruitment to the northwest Atlantic mackerel stock has been increasing in recent years (Table SA7). Following a period of poor year/classes from 1976 through 1980, there has been a series of years with relatively good recruitment with especially strong year classes in 1982, 1987 and 1988. These cohorts have contributed to the marked increase in stock biomass in recent years (Table SA8). This increase in biomass and the relatively stable catches in recent years produce a perceived decrease in the fishing mortality rates in 1989 and 1990. The time series of mean spawning stock biomass (1000s MT) is given below:

1962 - 174.6	1972 - 1287.8	1982 - 569.8
1963 - 191.4	1973 - 941.0	1983 - 596.0
1964 - 211.0	1974 - 734.2	1984 - 974.4
1965 - 231.8	1975 - 576.2	1985 - 1427.6
1966 - 258.0	1976 - 558.4	1986 - 1499.6
1967 - 280.6	1977 - 665.2	1987 - 1516.4
1968 - 513.4	1978 - 870.2	1988 - 1682.2
1969 - 943.2	1979 - 826.8	1989 - 1866.4
1970 - 1149.4	1980 - 756.8	1990 - 2421.6
1971 - 1207.8	1981 - 613.6	

SARC Analyses

The SARC calculated yield per recruit and spawning stock biomass per recruit (Figure SA1) using current data on growth, mortality and maturity.

Yield per Recruit Input Parameters

Age	Fish Mort Pattern	M	Proportion Mature	Average Weight Stock	Average Weight Catch
1	0.04	0.2	0.0	0.098	0.104
2	0.24	0.2	0.5	0.221	0.206
3	0.49	0.2	1.0	0.343	0.332
4	0.61	0.2	1.0	0.408	0.450
5	1.0	0.2	1.0	0.453	0.477
6	1.0	0.2	1.0	0.521	0.528
7	1.0	0.2	1.0	0.576	0.625
8	1.0	0.2	1.0	0.666	0.666
9	1.0	0.2	1.0	0.738	0.738
10	1.0	0.2	1.0	0.753	0.753
11+	1.0	0.2	1.0	0.779	0.779

Biological reference point estimates were updated using this analysis. A stock and recruitment plot for mackerel (Figure SA2) was used to calculate the F_{med} reference point.

The SARC performed a sensitivity run of the ADAPT analysis that removed the 1987 survey which was consistently high for all age-classes. The concern was the potential for a disproportionately large influence of this survey point on the results, giving an increase in biomass in recent years. This modification had the effect of decreasing the estimated mean stock biomass from about 2.9 million MT to 2.4 million MT, but had little effect on the recent trends in biomass.

Stock Projections

Projections are based on the geometric mean of recruitment from 1980 through 1989 and a partial recruitment vector calculated as the geometric mean of partial recruitments from 1985 through 1989 assuming full recruitment at age 5 (Table SA9). Projections assumed the current fishing mortality rate of 0.02 for 1991 and either the current rate $F_{0.1}$ (0.27) or an intermediate value of F (0.10). Stock projections were made for recruitment levels at one standard deviation above and below the geometric mean. Because recruitment of age 1 fish has relatively little influence on catch or biomass projections and the low catch rates of recent years contribute to substantial uncertainty about existing stock size in 1991, it may be more informative to consider that the coefficient of variation for stock biomass assessed by ADAPT is approximately 0.6. This uncertainty in stock size is graphically depicted in Figure SA3 assuming a lognormal distribution of errors.

Major Sources of Uncertainty

Low catches relative to standing stock size result in uncertainties in the assessment of stock size and fishing mortality rates.

Survey coefficients of variation are high. This is in part due to year to year shifts in the distribution of the stock which results in variability in the availability of mackerel to the survey.

Recommendations

Because of the extremely low harvest rates on this stock annual assessments are unnecessary.

Atlantic mackerel assessment would be improved by a survey specifically designed for pelagic stocks.

Table SA1. Mackerel landings (mt) from NAFO SA 2-6 for 1960-1990.

Year	USA Commercial	USA Recreational	Canada	Other Countries	Commercial Total	Grand Total
1960	1396	2478	5957	0	7353	9831
1961	1361	-	5459	11	6831	6831
1962	938	-	6865	175	7978	7978
1963	1320	-	6473	1299	9092	9092
1964	1644	-	10960	801	13405	13405
1965	1998	4292	11590	2945	16533	20825
1966	2724	-	12821	7951	23496	23496
1967	3891	-	11243	19047	34181	34181
1968	3929	-	20819	65747	90495	90495
1969	4364	-	17364	114189	135917	135917
1970	4049	16039	19959	210864	234872	250911
1971	2406	-	24496	355892	382794	382794
1972	2006	-	22360	391464	415830	415830
1973	1336	-	38514	396759	436609	436609
1974	1042	-	44655	321837	367534	367534
1975	1974	5190	36258	271719	309951	315141
1976	2712	-	33065	223275	259052	259052
1977	1377	-	22765	56067	80209	80209
1978	1605	-	25899	841	28345	28345
1979	1990	3588	30612	440	33042	36630
1980	2683	2364	22296	566	25545	27909
1981	2941	8505	19355	5361	27657	36162
1982	3330	1162	16383	6647	26360	27522
1983	3805	3280	19806	5955	29566	32846
1984	5954	2618	18233	15045	39232	41850
1985	6632	3287	30906	32409	69947	73234
1986	9637	3943	31097	25355	66089	70032
1987	12310	5567	22173	35094	69577	75144
1988	12309	4204	23288	42858	78455	82659
1989	14556	2251	18659	36823	70038	72289
1990[1]	31261	2000	18200	9126	58587	60587
1991[1]	24164	2000	18000	5349	47513	49513

1 preliminary

Table SA2. Mackerel commercial and recreational catch at age (millions of fish) from NAFO SA 2-6 during 1962-90[1].

Year	Age 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total	Mean age
1962	-	16.1	2.8	15.2	3.8	1.2	1.6	1.4	0.8	0.4	0.1	0.3	-	-	-	43.7	2.8
1963	-	1.1	4.2	1.3	26.3	6.0	0.3	0.2	0.2	0.2	0.1	0.1	-	-	-	40.0	4.1
1964	-	12.9	7.0	4.1	4.0	19.4	4.1	3.9	0.7	0.8	0.2	-	-	-	-	57.1	3.8
1965	-	9.0	3.6	2.9	4.0	5.2	19.5	4.2	4.0	0.7	-	-	-	-	-	53.1	4.7
1966	-	24.0	11.5	5.3	2.6	4.7	7.9	21.8	0.5	0.2	-	-	-	-	-	78.5	3.9
1967	1.8	0.8	26.7	19.8	3.5	3.3	5.1	6.1	32.3	0.3	-	-	-	-	-	99.7	4.8
1968	1.1	141.4	61.5	59.3	38.1	14.3	6.6	0.7	1.0	6.1	0.1	-	-	-	-	330.2	2.3
1969	4.0	7.1	262.1	160.7	65.8	5.7	3.0	2.0	3.1	2.2	8.3	-	-	-	-	524.0	2.8
1970	4.8	193.5	54.5	522.1	162.9	27.6	7.0	5.3	9.9	10.0	3.8	2.8	-	-	-	1,004.2	3.0
1971	2.4	74.6	294.2	127.4	558.9	203.5	34.6	8.9	3.6	4.3	8.1	7.2	-	-	-	1,327.7	3.6
1972	3.6	22.1	85.7	256.2	182.6	390.4	87.3	24.0	4.2	8.2	3.8	5.6	-	-	-	1,073.7	4.2
1973	4.0	161.8	283.2	285.1	233.6	192.4	197.2	31.2	11.0	4.1	3.8	1.6	-	-	-	1,409.0	3.6
1974	2.0	95.9	242.2	264.4	101.5	114.3	111.8	108.3	25.7	6.4	2.5	0.8	-	-	-	1,075.8	3.8
1975	3.7	373.7	431.4	113.7	100.8	58.6	67.8	51.9	50.5	12.5	2.3	1.0	-	-	-	1,267.9	2.8
1976	-	12.5	353.5	272.5	85.7	52.4	27.3	40.5	34.6	22.6	13.4	1.4	-	-	-	916.4	3.5
1977	-	2.0	27.0	101.0	54.0	12.0	9.9	5.6	6.3	3.8	3.6	0.3	0.3	-	-	225.8	3.8
1978	-	0.1	0.2	4.7	17.4	13.3	8.4	4.7	2.2	4.5	1.5	4.6	0.6	0.6	-	62.8	5.9
1979	-	0.4	0.6	1.3	7.1	18.6	13.1	6.2	2.6	2.2	2.3	0.7	1.9	0.6	1.0	58.6	6.2
1980	-	1.2	10.9	1.0	1.0	6.9	13.8	4.7	2.0	1.0	1.0	1.6	0.5	1.3	0.8	47.7	5.6
1981	+	10.4	4.8	8.7	2.0	2.8	7.9	13.1	5.6	2.7	0.9	0.4	0.4	0.7	0.8	61.2	5.1
1982	+	3.6	9.9	2.7	8.4	1.2	2.7	4.4	8.1	2.6	1.3	0.6	0.3	0.7	1.3	47.8	5.4
1983	-	2.2	14.2	4.5	1.4	6.8	0.7	1.3	4.8	11.8	5.3	1.2	0.7	0.4	0.8	56.0	5.9
1984	-	0.5	44.0	29.7	3.4	1.2	4.7	0.6	0.6	3.4	7.8	2.9	0.9	0.6	1.6	102.0	4.1
1985	-	3.4	1.9	140.9	33.7	2.7	0.8	3.2	0.2	0.5	2.4	4.5	2.4	0.6	1.2	198.6	3.7
1986	-	1.5	12.3	6.7	93.9	23.1	1.9	0.5	3.5	0.2	0.7	1.5	2.4	0.7	0.7	149.6	4.4
1987	-	10.0	16.6	14.5	7.8	112.2	17.9	2.7	0.4	2.2	0.3	0.5	1.0	1.6	0.5	188.1	4.7
1988	-	2.5	13.7	10.6	11.9	11.0	110.2	22.3	2.6	1.2	0.9	0.7	1.1	1.1	1.8	190.8	5.7
1989	+	2.5	15.6	11.2	7.5	6.7	2.3	87.0	4.6	0.8	0.4	0.5	0.2	0.3	0.4	140.0	5.9
1990	+	3.1	22.9	33.7	9.6	8.1	4.7	0.2	52.5	2.3	0.5	0.3	0.2	0.2	0.3	138.4	5.2

1 includes estimated recreational catches for 1961-1964, 1966-1969, 1971-1974, 1976-1978.

Table SA3. Commercial mean weight-at-age for Atlantic mackerel from 1962 to 1990 landings.

	age													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1962[1]	.130	.208	.289	.365	.433	.491	.541	.581	.614	.641	.662	.000	.000	.000
1963	.120	.192	.264	.334	.395	.448	.492	.529	.559	.583	.602	.000	.000	.000
1964	.116	.188	.262	.332	.395	.450	.495	.533	.564	.588	.000	.000	.000	.000
1965	.123	.200	.278	.352	.419	.477	.525	.565	.598	.000	.000	.000	.000	.000
1966	.128	.209	.294	.374	.447	.509	.562	.605	.641	.000	.000	.000	.000	.000
1967	.123	.202	.283	.360	.428	.489	.540	.581	.615	.000	.000	.000	.000	.000
1968	.148	.241	.335	.425	.506	.576	.634	.683	.722	.753	.000	.000	.000	.000
1969	.131	.214	.300	.382	.456	.520	.574	.618	.654	.683	.000	.000	.000	.000
1970	.107	.179	.253	.324	.389	.444	.491	.530	.562	.587	.608	.000	.000	.000
1971	.110	.181	.256	.327	.391	.446	.494	.532	.564	.589	.610	.000	.000	.000
1972	.123	.210	.300	.386	.464	.533	.590	.638	.677	.708	.733	.000	.000	.000
1973	.113	.189	.269	.345	.414	.473	.524	.565	.600	.628	.650	.000	.000	.000
1974	.111	.190	.273	.352	.425	.487	.541	.585	.621	.649	.673	.000	.000	.000
1975	.104	.176	.252	.326	.393	.451	.500	.540	.573	.600	.621	.000	.000	.000
1976	.097	.168	.244	.316	.382	.440	.489	.530	.563	.590	.611	.000	.000	.000
1977	.114	.198	.288	.375	.454	.524	.582	.631	.671	.703	.729	.749	.000	.000
1978	.192	.285	.425	.463	.509	.582	.625	.659	.673	.697	.717	.797	.705	.000
1979	.190	.272	.531	.567	.579	.603	.652	.714	.752	.769	.822	.809	.842	.830
1980	.146	.376	.548	.609	.617	.635	.672	.705	.781	.743	.785	.773	.775	.778
1981	.114	.315	.523	.577	.643	.660	.674	.707	.723	.756	.772	.812	.780	.801
1982	.152	.340	.541	.606	.666	.743	.737	.722	.719	.740	.790	.811	.798	.829
1983	.098	.257	.479	.593	.628	.659	.712	.709	.705	.727	.735	.752	.744	.805
1984	.098	.162	.338	.525	.625	.657	.696	.715	.705	.709	.726	.755	.775	.770
1985	.111	.260	.277	.416	.558	.644	.677	.665	.737	.717	.715	.739	.731	.782
1986	.079	.234	.349	.366	.452	.581	.640	.729	.777	.750	.738	.717	.776	.781
1987	.107	.210	.316	.404	.411	.505	.502	.706	.747	.680	.750	.736	.781	.775
1988	.100	.222	.343	.408	.453	.484	.584	.694	.755	.815	.762	.775	.790	.761
1989	.100	.231	.375	.414	.474	.509	.529	.631	.753	.803	.816	.825	.801	.893
1990	.104	.206	.332	.450	.477	.528	.625	.572	.659	.718	.828	.806	.808	.853

1. Data for 1962-1983 are from Anderson (1984).

Table SA4. Mackerel stratified mean wt and number per tow from NEFC spring research surveys for stratas 1-25 and 61-76 for 1968-1990 for standard and log transformed data. Smoothed values were obtained from a Integrated Moving Average (IMA) model.

	STANDARD		SMOOTHED		LOG		SMOOTHED	
YEAR	WT	NUMBER	WT	NUMBER	WT	NUMBER	WT	NUMBER
68	5.609	70.869	1.147	10.016	1.669	15.253	0.413	2.289
69	0.055	0.484	0.935	5.944	0.031	0.178	0.345	1.601
70	2.200	9.356	1.098	6.886	0.871	2.528	0.393	1.694
71	3.145	12.668	1.179	7.350	0.887	2.773	0.404	1.662
72	1.542	8.490	1.116	6.786	0.603	2.260	0.375	1.480
73	6.746	20.973	1.013	5.902	0.382	1.199	0.328	1.218
74	0.656	2.241	0.720	3.661	0.335	1.129	0.281	1.004
75	0.242	3.540	0.519	2.588	0.167	0.986	0.235	0.811
76	0.254	1.800	0.412	1.683	0.141	0.541	0.206	0.630
77	0.081	0.287	0.348	1.075	0.071	0.195	0.189	0.505
78	0.345	0.970	0.354	0.976	0.193	0.429	0.197	0.483
79	0.089	0.172	0.362	0.888	0.080	0.146	0.205	0.473
80	0.202	0.559	0.444	1.251	0.140	0.310	0.242	0.578
81	2.470	5.872	0.602	2.187	0.744	1.565	0.306	0.794
82	0.854	5.167	0.678	2.936	0.359	0.998	0.345	0.960
83	0.135	0.884	0.743	3.386	0.112	0.551	0.387	1.153
84	2.611	16.228	1.015	5.588	0.883	2.463	0.510	1.591
85	2.232	8.242	1.227	6.939	0.924	2.685	0.626	2.021
86	1.264	4.178	1.482	8.231	0.443	1.196	0.730	2.434
87	7.492	35.231	1.828	11.699	3.208	11.531	0.909	3.351
88	4.133	16.792	1.881	12.392	2.056	5.560	0.961	3.655
89	1.100	12.273	1.749	12.104	0.668	3.841	0.922	3.684
90[1]	1.548	10.748	1.723	11.780	0.824	3.645		

1 preliminary

Table SA5. Catch per tow at age (NUMBERS) for Atlantic mackerel from Spring groundfish surveys for strata 1-25, 61-76 for 1968-1990. Values are log retransformed.

	AGE													
YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14
68	12.9400	0.4150	0.1894	0.0523	0.0164	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
69	0.0297	0.1418	0.0167	0.0058	0.0003	0.0007	0.0005	0.0009	0.0004	0.0004	0.0000	0.0000	0.0000	0.0000
70	0.2795	0.1845	1.3910	0.6115	0.1812	0.0617	0.0549	0.0877	0.0827	0.0447	0.0026	0.0000	0.0000	0.0000
71	0.3282	0.9409	0.4383	1.1250	0.3929	0.0621	0.0141	0.0073	0.0062	0.0048	0.0035	0.0000	0.0000	0.0000
72	0.8719	0.3077	0.5929	0.2261	0.3254	0.0583	0.0112	0.0011	0.0018	0.0004	0.0000	0.0000	0.0000	0.0000
73	0.3514	0.3398	0.1758	0.2338	0.1262	0.2846	0.1821	0.1524	0.0460	0.0367	0.0033	0.0291	0.0181	0.0150
74	0.3478	0.1796	0.2358	0.0478	0.0985	0.0599	0.2084	0.0912	0.0590	0.0117	0.0115	0.0000	0.0000	0.0000
75	0.6544	0.2298	0.0409	0.0226	0.0064	0.0073	0.0043	0.0039	0.0034	0.0000	0.0000	0.0000	0.0000	0.0000
76	0.0959	0.3871	0.0710	0.0135	0.0024	0.0006	0.0028	0.0004	0.0019	0.0003	0.0003	0.0000	0.0000	0.0000
77	0.0095	0.0472	0.0850	0.0453	0.0154	0.0052	0.0028	0.0070	0.0038	0.0054	0.0010	0.0075	0.0000	0.0000
78	0.0502	0.1097	0.1032	0.1943	0.0958	0.0284	0.0110	0.0027	0.0148	0.0000	0.0164	0.0000	0.0013	0.0000
79	0.0105	0.0037	0.0072	0.0126	0.0495	0.0144	0.0103	0.0057	0.0057	0.0190	0.0042	0.0156	0.0030	0.0064
80	0.0234	0.1877	0.0066	0.0048	0.0233	0.0489	0.0110	0.0107	0.0070	0.0017	0.0096	0.0000	0.0107	0.0064
81	0.3355	0.1371	0.4294	0.0476	0.0463	0.1613	0.4041	0.2302	0.1385	0.0704	0.0673	0.0844	0.0769	0.1031
82	0.4323	0.1950	0.0215	0.0979	0.0182	0.0102	0.0245	0.0965	0.0440	0.0266	0.0156	0.0122	0.0200	0.0092
83	0.2357	0.2873	0.0222	0.0016	0.0036	0.0006	0.0002	0.0014	0.0022	0.0004	0.0008	0.0006	0.0002	0.0000
84	0.2598	1.8014	0.6055	0.0415	0.0050	0.0432	0.0036	0.0025	0.0161	0.0470	0.0153	0.0075	0.0041	0.0098
85	0.3382	0.0846	1.8513	0.2348	0.0277	0.0107	0.0469	0.0032	0.0097	0.0416	0.0666	0.0405	0.0119	0.0258
86	0.1301	0.4497	0.0778	0.5908	0.1177	0.0080	0.0014	0.0196	0.0004	0.0019	0.0184	0.0101	0.0054	0.0116
87	1.4842	1.7945	0.8742	0.3719	2.9450	0.4967	0.1427	0.0156	0.1383	0.0058	0.0406	0.0412	0.1202	0.0482
88	0.6336	0.4577	0.3666	0.3357	0.3748	1.7688	0.4428	0.0513	0.0478	0.0405	0.0426	0.0764	0.0519	0.0118
89	1.5826	1.6407	0.0707	0.2841	0.0087	0.0108	0.0666	0.0086	0.0050	0.0044	0.0060	0.0020	0.0029	0.0029
90	1.3003	1.3849	0.5010	0.0157	0.0129	0.0059	0.0004	0.0762	0.0094	0.0043	0.0026	0.0014	0.0045	0.0029

Table SA6: Fishing Mortality at age for Atlantic Mackerel Estimated by ADAPT

Year

Age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	0.0605	0.0059	0.0622	0.0342	0.0396	0.0004	0.0318	0.0038	0.0879	0.0629	0.0180	0.1684	0.0561	0.1843	0.0285	0.0151
2	0.0173	0.0201	0.0471	0.0221	0.0559	0.0564	0.0423	0.0759	0.0360	0.1872	0.0956	0.3335	0.4086	0.3812	0.2663	0.0793
3	0.0330	0.0099	0.0245	0.0247	0.0411	0.1289	0.1714	0.1485	0.2129	0.1106	0.2471	0.5232	0.6004	0.3416	0.4431	0.1126
4	0.1417	0.0735	0.0382	0.0300	0.0277	0.0344	0.3905	0.2921	0.2210	0.3714	0.2291	0.3741	0.3552	0.4832	0.4699	0.1450
5	0.0826	0.3474	0.0712	0.0638	0.0446	0.0446	0.1920	0.0913	0.1909	0.4737	0.4840	0.4026	0.3163	0.3577	0.5016	0.1082
6	0.4811	0.0266	0.4258	0.0949	0.1305	0.0624	0.1181	0.0558	0.1548	0.3888	0.3820	0.4846	0.4336	0.3141	0.2806	0.1629
7	0.6725	0.0991	0.5597	1.0910	0.1461	0.1409	0.0109	0.0475	0.1321	0.3012	0.5152	0.2270	0.5418	0.3678	0.3137	0.0846
8	0.1799	0.1831	0.5893	2.8080	0.3389	0.3351	0.0308	0.0608	0.3484	0.1246	0.2264	0.4737	0.2963	0.5268	0.4494	0.0726
9	0.2364	0.0621	4.0148	3.9359	3.0219	0.3505	0.0963	0.0877	0.2838	0.2499	0.4608	0.3608	0.5631	0.2292	0.4765	0.0792
10	0.1724	0.0849	0.0814	0.0867	0.0917	0.1270	0.1874	0.1839	0.2149	0.3926	0.3658	0.4024	0.3910	0.4033	0.4114	0.1264
11	0.1724	0.0849	0.0814	0.0867	0.0917	0.1270	0.1874	0.1839	0.2149	0.3926	0.3658	0.4024	0.3910	0.4033	0.4114	0.1264

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.0021	0.0020	0.0137	0.0495	0.0028	0.0005	0.0013	0.0030	0.0011	0.0117	0.0009	0.0006	0.0026
2	0.0019	0.0152	0.0707	0.0697	0.0608	0.0137	0.0116	0.0049	0.0135	0.0150	0.0200	0.0066	0.0063
3	0.0177	0.0149	0.0318	0.0741	0.0509	0.0354	0.0358	0.0466	0.0212	0.0197	0.0119	0.0204	0.0176
4	0.0254	0.0335	0.0142	0.0821	0.0951	0.0336	0.0338	0.0519	0.0396	0.0309	0.0202	0.0104	0.0218
5	0.0481	0.0342	0.0413	0.0501	0.0648	0.1038	0.0365	0.0340	0.0456	0.0608	0.0556	0.0141	0.0139
6	0.1028	0.0611	0.0320	0.0608	0.0624	0.0489	0.0947	0.0307	0.0301	0.0452	0.0781	0.0147	0.0123
7	0.1082	0.1028	0.0280	0.0384	0.0435	0.0386	0.0539	0.0882	0.0241	0.0546	0.0729	0.0816	0.0016
8	0.0433	0.0804	0.0436	0.0422	0.0300	0.0611	0.0224	0.0344	0.1315	0.0241	0.0682	0.0192	0.0647
9	0.0679	0.0556	0.0401	0.0763	0.0247	0.0558	0.0561	0.0233	0.0289	0.1142	0.0937	0.0269	0.0119
10	0.0405	0.0449	0.0322	0.0460	0.0477	0.0644	0.0474	0.0510	0.0412	0.0552	0.0623	0.0408	0.0210
11	0.0405	0.0449	0.0322	0.0460	0.0477	0.0644	0.0474	0.0510	0.0412	0.0552	0.0623	0.0408	0.0210

Table SA7: Stock Numbers (tens of millions : Jan 1) for Atlantic Mackerel Estimated by ADAPT

Age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	303	207	236	295	683	2003	4999	2087	2541	1352	1372	1154	1943	2454	492	148	54	216	97	238	1414
2	181	234	168	182	234	538	1639	3965	1702	1905	1039	1104	798	1504	1671	391	119	44	176	79	185
3	518	145	187	131	146	181	416	1287	3009	1344	1293	773	647	434	841	1048	296	97	35	135	60
4	32	410	118	150	105	114	130	287	908	1991	985	827	375	291	253	442	767	238	79	28	102
5	17	23	312	93	119	84	90	72	175	596	1125	642	466	215	147	129	313	612	189	63	21
6	5	13	13	238	71	93	65	61	54	119	304	567	351	278	123	73	95	244	484	148	49
7	3	2	10	7	177	51	72	48	47	38	66	170	286	186	166	76	51	70	188	384	114
8	5	1	2	5	2	125	36	58	37	34	23	32	111	136	106	99	57	37	52	150	303
9	2	4	1	1	0	1	73	29	45	21	25	15	16	67	66	55	76	45	28	41	118
10	1	1	3	0	0	0	1	55	22	28	14	13	9	8	44	33	42	58	35	22	31
11	2	1	0	0	0	0	0	0	16	24	20	5	3	3	5	6	161	106	146	56	69

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	5164	531	1243	1496	946	3218	4921	1311	0
2	1154	4226	434	1015	1224	766	2632	4027	1071
3	143	932	3420	354	820	987	614	2141	3276
4	47	113	736	2673	283	658	798	493	1722
5	76	37	89	572	2103	225	528	647	395
6	16	56	29	71	448	1621	174	426	522
7	38	13	42	23	56	350	1227	141	345
8	89	30	10	31	19	44	267	926	115
9	240	69	24	8	23	15	33	214	711
10	94	186	53	19	6	16	11	27	173
11	55	140	193	145	74	86	39	53	64

Table SA8: Mean Biomass of Atlantic Mackerel (1000 MT) Estimated by ADAPT.

Age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	34.7	22.4	24.1	32.4	77.8	223.3	660.4	247.3	236.2	130.8	151.7	109.0	190.3	211.9	42.7	15.1
2	33.8	40.3	28.0	32.6	43.1	95.8	350.9	741.5	271.4	285.9	189.0	161.6	113.6	200.8	224.3	67.6
3	133.5	34.6	44.0	32.7	38.0	43.6	116.5	325.9	623.7	295.8	312.9	148.1	121.6	84.5	151.4	259.2
4	9.8	119.9	34.8	47.1	35.1	36.7	41.8	86.6	240.1	496.0	309.3	217.1	101.4	68.7	58.2	140.2
5	6.3	6.9	108.0	34.2	47.2	31.8	37.9	28.6	56.5	169.6	377.9	199.5	154.6	64.9	40.3	50.5
6	1.6	5.1	4.4	98.3	30.9	40.1	32.3	28.0	20.2	40.0	122.8	194.3	126.7	98.0	43.1	32.0
7	1.1	1.0	3.5	2.1	84.2	23.5	41.0	24.2	19.8	14.7	27.8	72.4	109.3	71.1	63.6	38.6
8	2.6	0.6	0.6	0.8	0.9	56.4	22.2	31.6	15.2	15.4	11.9	13.2	51.1	52.3	41.2	54.9
9	1.0	1.8	0.1	0.1	0.0	0.5	45.9	16.5	19.9	9.8	12.2	6.9	7.1	31.4	27.0	32.3
10	0.4	0.7	1.4	0.0	0.0	0.0	0.4	31.0	10.4	12.3	7.4	6.0	4.2	3.5	19.4	20.1
11	1.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0	7.9	11.2	11.2	2.6	1.4	1.5	2.1	3.5
1+	226.1	234.0	249.1	280.4	357.3	551.7	1349.2	1561.2	1521.4	1481.4	1534.0	1130.8	981.3	888.6	713.1	714.2

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	9.3	37.2	12.8	24.0	194.5	458.6	47.1	124.9	107.1	91.2	291.5	445.9	123.4
2	30.7	10.7	58.1	21.7	55.5	267.1	617.1	102.0	213.8	231.2	152.6	549.3	749.6
3	113.1	46.5	17.3	61.6	28.8	61.0	280.7	839.6	110.7	232.6	305.0	206.8	638.7
4	317.8	120.4	43.0	14.1	53.7	24.7	52.9	270.8	869.9	102.2	241.0	298.1	198.9
5	141.2	315.9	103.4	36.1	12.4	41.3	20.6	44.5	229.4	761.0	89.9	225.3	277.8
6	47.7	129.7	274.4	86.1	32.3	9.5	32.0	16.8	36.7	200.5	684.7	79.8	202.8
7	27.2	39.5	113.1	230.3	74.6	24.1	7.8	24.6	13.3	24.9	179.1	565.7	79.6
8	33.6	23.2	32.4	94.1	195.1	55.8	19.2	5.8	19.5	11.7	26.5	151.1	465.3
9	44.7	29.8	19.5	25.7	75.7	149.5	42.9	15.8	5.4	14.4	9.7	22.4	127.2
10	25.9	39.5	23.1	14.8	20.2	60.0	116.9	33.8	12.8	3.7	11.8	7.9	17.1
11	103.6	76.8	101.5	39.6	49.3	36.5	92.9	124.8	95.0	49.8	58.2	28.7	39.3
1+	894.9	869.3	798.7	648.0	792.2	1188.1	1329.9	1603.5	1713.5	1723.3	2050.0	2581.0	2919.8

Table SA9: Mackerel catch and stock size projections (in 1000's of MT) for three levels of recruitment and three fishing mortality rates.

	1991(F=F90)			1992			1993
Recruitment	F	Land.	SSB	F	Land.	SSB	SSB
LOW= 305	0.02	38	3028	F90 =00.02	41	2943	2702
	0.02	38	3028	F0.1=0.27	579	2557	1891
MID=1096	0.02	38	3028	F90 =0.02	42	3008	2930
	0.02	38	3028	F0.1=0.27	611	2688	2114
HIGH=3942	0.02	38	3028	F90 =0.02	96	3240	3748
	0.02	38	3028	F0.1=027	587	2619	2093

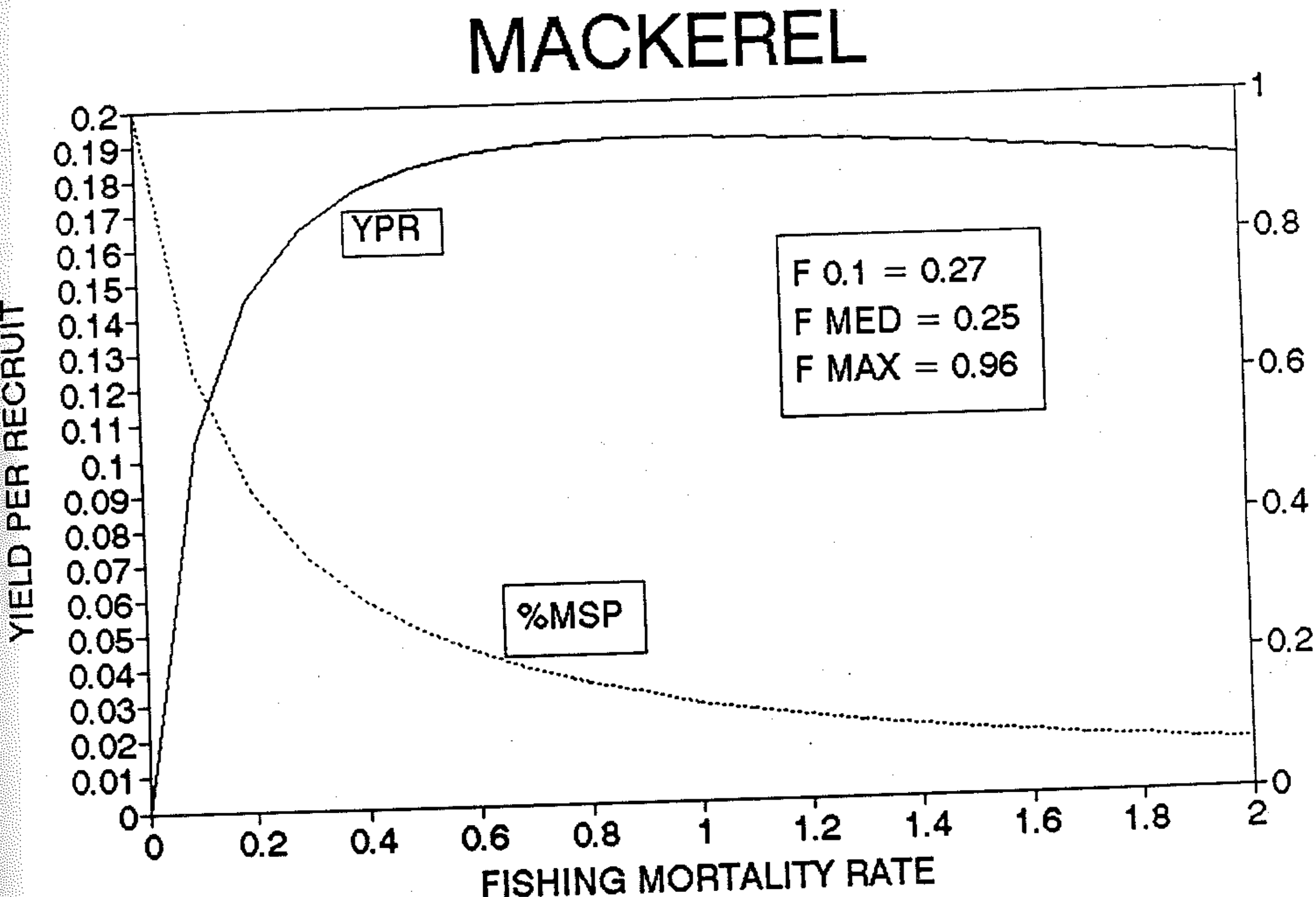


Figure SA1.Yield and spawning biomass per recruit for Atlantic mackerel. Biological reference points are indicated on the graph.

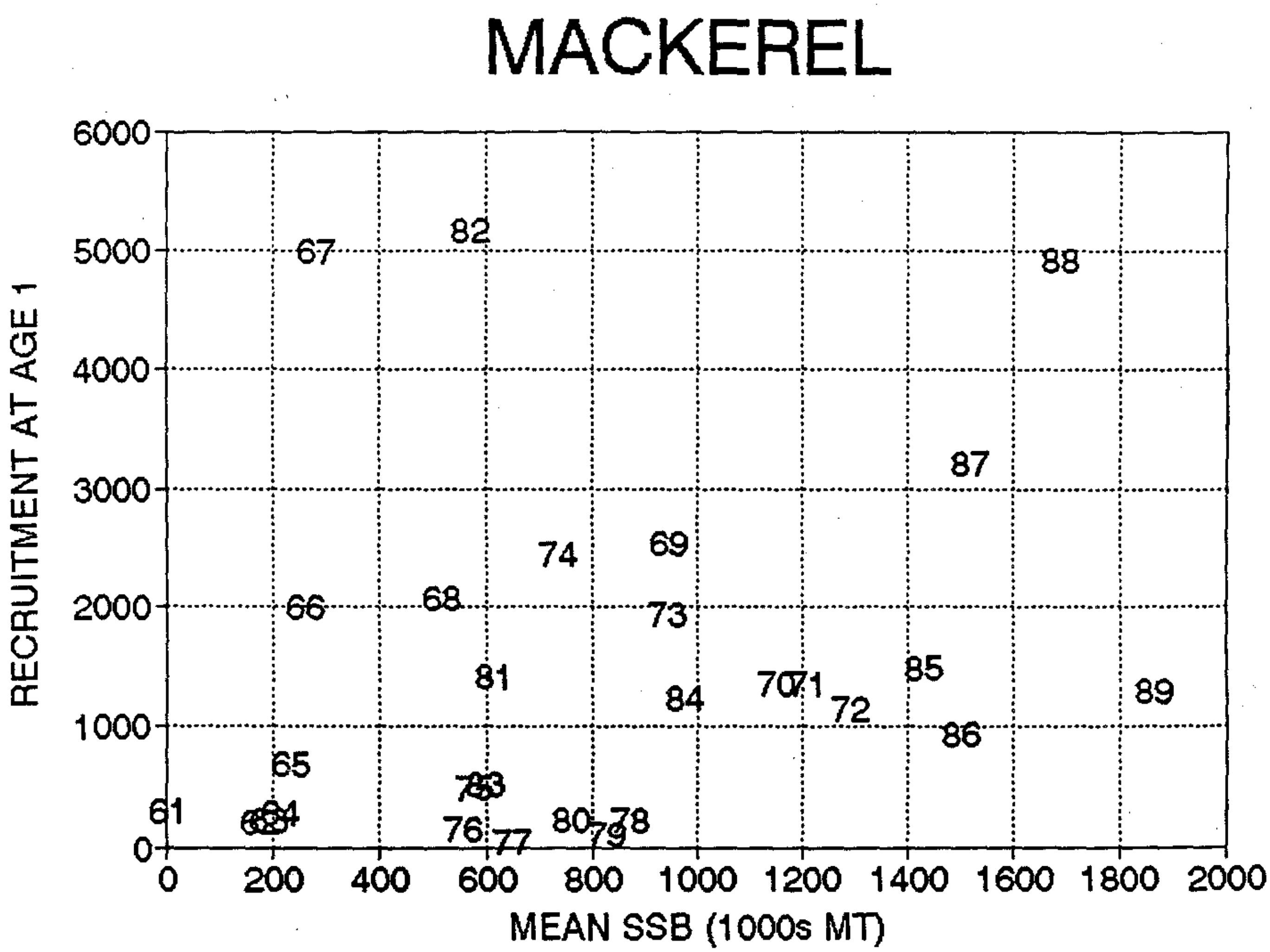


Figure SA2. Stock and recruitment data for Atlantic mackerel. Recruitment is in billions of fish. The datapoint labels give the year class for each cohort.

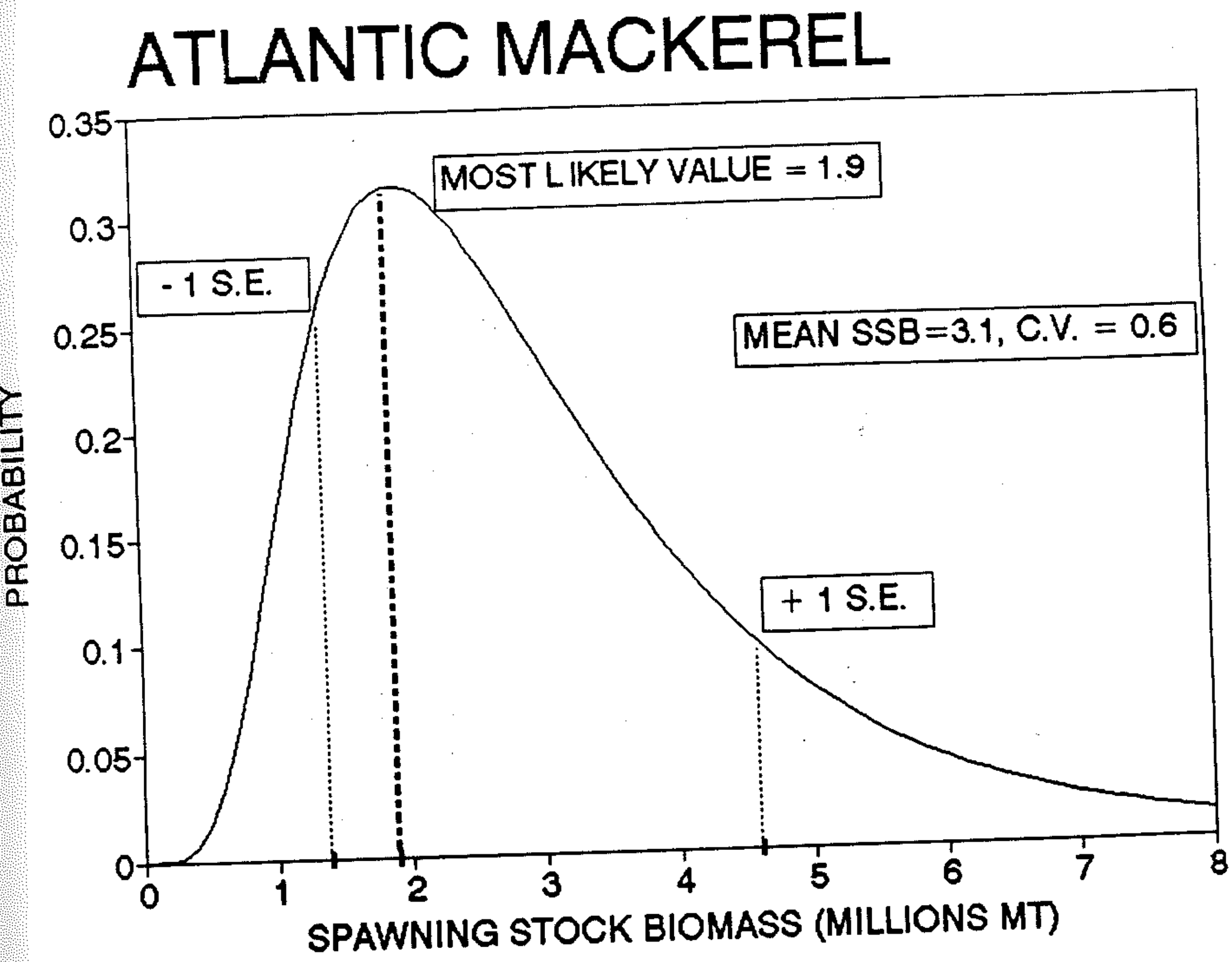


Figure SA3. Uncertainty plot for 1991 mackerel spawning biomass assuming the C.V. of the lognormally distributed 1991 projection estimate is 60%. Note that the most likely value is well below the mean estimate under the lognormal assumption.

ATLANTIC BUTTERFISH

Butterfish, Peprilus triacanthus, is one of four species [with Atlantic mackerel, long fin squid (Loligo pealei) and short fin squid (Illex illecebrosus)] which experienced heavy foreign fishing prior to implementation of the Magnuson Fisheries Conservation and Management Act (MFCMA). These four species have been managed under one FMP by the Mid Atlantic Fishery Management Council since the early 1980s. The SARC reviewed indices of abundance and estimates of total mortality rates of butterfish(SAW/12/SARC/2). The consensus was that the butterfish population is at a relatively high level of abundance and there is likely to be sufficient stock to support catches at the long term potential yield level of 16,000 MT. The resource appears to be under-exploited in the region.

Background

Butterfish range from Newfoundland to Florida and are present in commercially significant amounts between Cape Hatteras and Southern New England. The commercially exploited butterfish population is assumed to constitute a unit stock in waters north of Cape Hatteras. The stock north of Cape Hatteras migrates inshore and northward during the summer and returns to offshore waters in the winter due to temperature preferences (Murawski et al 1978).

Butterfish have been landed by domestic fishermen since the 1800s. Foreign catches began in the 1960s and the average landing per year increased to more than 11,000 MT in the late 1960s and early 1970s (Murawski and Waring 1979). Overall, landings have dropped since the displacement of the foreign fleet and currently average around 3,000 MT per annum (Table SB1). Details of landings by statistical area, month and market category are given in SAW/12/SARC/2.

Data Sources

Landings data for 1989 and 1990 were collected from Joint Venture, general canvas, and NMFS weighout data. Data for 1965-1988 were utilized from the Report of the 10th SAW (NEFC 1990).

The amount of butterfish discarded at present is unknown. There has been no sea sampling efforts directed at the freezer-trawlers because of the extended duration these vessels spend at sea. NEFC (1989) concluded "Discard rates of small butterfish in the domestic fishery during 1988 were low compared to rates reported in the early 1980s (<10% compared to 40-70% by weight of landed catch)". The nominal catch figures have not been adjusted for discards in Table SB1.

An index of relative abundance of butterfish is available from the NEFC autumn bottom trawl survey for 1968-1990. Stratified mean number per tow and mean weight per tow indices are given in Table SB2. The stratified mean number per tow index was disaggregated to a mean number per tow at age using annual age length keys derived from the survey data in each year.

Age at 50% maturity for butterfish is 1.5 years at a size of 14.0 cm. The maximum age is about 6 years and the instantaneous rate of natural mortality is assumed to be 0.8.

Methodology

The primary methodology used for this assessment is examination of the research survey indices with respect to historical patterns. This follows on from previous butterfish assessment (NEFC 1990).

Assessment Results

Catch per unit effort (CPUE) statistics for the directed domestic butterfish fishery during 1982-1990 were developed (Table SB3). Directed effort is defined as total landings (MT) divided by total days fished for vessels over 5 GRT landing over 50% butterfish on a trip. The number of directed trips decreased in the late 1980s, and the number of directed trips in 1990 was less than 1/3 the average for the 1982-1990 period. Similarly, directed CPUE for butterfish has decreased in the late 1980s, and in 1990 is roughly 1/2 the average for the 1982-1990 period. Overall, 1989 and 1990 were similar in terms of directed CPUE, although there were more directed trips in 1989. The SARC concluded that, as with other stocks, a better definition of the directed fishery may be obtained with a statistically based method such as general linear modelling of the CPUE data.

The 1990 autumn pre-recruit index (stratified mean number of age 0 per tow) was 201% of the mean age 0 index for the 1968-1990 period. However, the 1990 recruit index (stratified mean number of age 1+ per tow) was only 85% of the mean age 1+ index. The pattern of high pre-recruit indices has continued since 1988 (Table SB2). Although there was a 42% decline in the butterfish recruit index (Age 1+) from 1989, this index is still at a high level in comparison to the early 1970s and the decline is a result of high mortality on the 1987 and 1988 year-classes.

The 95% CI for the mean number per tow index for the 1990 survey is 206 to 527 with a CV of 22%. The 95% CI for the 1989 index is 127 to 669 with a CV of 35%.

The three year moving average of the pre-recruit index provides reference points for butterfish abundance, and this moving average was 314 for 1990. This is well above the lowest quartile of the historical indices and, because of the nature of the moving average and the high pre-recruit indices in 1989 and 1990, this measure will remain high (above the threshold in the Mid-Atlantic Fishery Management Council's (MAFMC) definition of over-fishing) for the next two years.

Other biological reference points (NEFC 1989) assuming an $M=0.80$ are: $F_{0.1}=1.60$, $F_{max}>2.50$.

Estimates of total instantaneous mortality (Z) for butterfish were derived from stratified mean number per tow at age data (Table SB4). Overall, the 1990 mortality rate estimates are higher than the 1978-1990 means (Table SB4), although abundance indices are at or above their average levels for the period 1968-1990 .

Relatively high total mortality estimates for the 1987 to 1989 year classes may be the result of increased natural predation and discarding. Butterfish co-occur with Loligo pealei (Lange and Waring 1990) and discarding of butterfish in directed Loligo fisheries during 1989 may have negatively impacted older age classes. Nonetheless, given the high level of pre-recruit abundance, stock relative abundance in 1991 is likely to remain high.

SARC Analyses

The SARC had no major difficulties with the analyses presented. There was concern over the apparent increasing Z estimates while commercial catches have decreased and abundance has increased. Speculation focused on the possibilities of increasing M, changes in availability of butterfish, and changes in fishing (for both butterfish and Loligo spp.) patterns.

Projections

No projections were made; however, there appears no reason why long term potential catch levels could not be supported by the present biomass for the next several years.

Major Sources of Uncertainty

- Discards from freezer trawlers and the inshore Loligo fishery, or other small mesh fisheries may be an important source of removals from the stock.

- Differences in the availability of various age groups to the survey mean that there may be substantial uncertainty in the estimates of total mortality rate and pre-recruit indices.

- Uncertainty in M with respect to biological reference points.

Recommendations

- o Recalculate yield per recruit curve including the sensitivity to the natural mortality rate.
- o Develop a statistically based analysis of the directed fishery.
- o Document discarding of butterfish, especially by the large freezer trawlers.
- o Integrate the inshore surveys of MA and CT into the assessment.
- o Develop a survey specifically designed for pelagic stocks.

Table SB1. Domestic and foreign landings (MT) of butterfish from Northwesr Atlantic Fishing Organization subareas 5 and 6, 1965-1990.

Year	Domestic	Foreign	Total
1965	3,340	749	4,089
1966	2,615	3,865	6,480
1967	2,452	2,316	4,768
1968	1,804	5,437	7,241
1969	2,438	15,073	17,511
1970	1,869	9,028	10,897
1971	1,570	6,238	7,853
1972	819	5,671	6,490
1973	1,557	17,847	19,454
1974	2,528	10,337	12,865
1975	2,088	9,077	11,165
1976	1,528	10,353	11,881
1977	1,448	3,205	4,653
1978	3,676	1,326	5,002
1979	2,831	840	3,671
1980	5,356	879	6,235
1981	4,855	936	5,791
1982	9,060	631	9,691
1983	4,905	630	5,535
1984	11,972	429	12,401
1985	4,739	804	5,543
1986	4,418	164	4,582
1987	4,508	0	4,508
1988	2,083	0	2,083
1989	3,192	1	3,193
1990	2,395	3	2,398

Table SB2. Butterfish abundance indices derived from NEFC autumn bottom trawl survey data. Indices are stratified mean number and mean weight (kg.) of Butterfish per tow.

Stratified mean number per tow at age

	Age						Mean	
Year	0	1	2	3	4	Total	Age 1+	weight (kg)
1968	41.28	50.59	1.64	0.10	0	93.61	52.3	7.7
1969	39.48	18.82	2.12	0.16	0	60.58	21.1	3.9
1970	26.43	11.24	0.86	0.10	0	38.63	12.2	2.3
1971	208.85	8.76	0.70	0.24	0	218.55	9.6	4.3
1972	73.20	8.34	0.31	0.05	0	81.90	8.7	2.7
1973	119.10	27.73	1.50	0.07	0	148.40	29.3	6.1
1974	82.13	15.96	1.74	0.37	0	100.20	18.0	3.8
1975	26.34	17.54	1.71	0.15	0	45.74	19.4	2.3
1976	110.63	26.50	2.12	0.33	0	139.58	29.0	5.8
1977	47.73	32.78	6.22	0.24	0	86.97	39.3	5.2
1978	134.96	7.96	10.18	1.05	0	154.15	19.2	4.3
1979	231.51	73.01	4.85	0.18	0	309.55	78.1	12.1
1980	233.19	80.42	18.82	0.73	0.04	333.20	100.0	15.2
1981	234.55	47.14	12.88	0.29	0.01	294.87	60.3	7.0
1982	80.31	26.12	4.73	0.14	0.14	111.44	30.7	4.7
1983	358.77	78.49	10.70	3.25	0.07	451.28	92.5	12.8
1984	268.60	79.55	11.07	2.79	0	362.01	93.4	11.4
1985	286.26	85.69	12.40	2.27	0.09	386.71	100.4	15.2
1986	140.16	29.75	12.19	1.96	0.33	184.39	44.3	6.8
1987	78.59	31.55	7.17	0.25	0	117.56	39.0	4.7
1988	282.28	21.59	13.29	0.20	0	317.36	35.1	7.3
1989	332.31	49.95	15.05	1.03	0	398.34	66.0	12.2
1990	328.29	33.35	3.89	0.95	0	366.57	38.3	8.9
Mean	163.69	37.51	6.79	0.73	0.03	208.76	45.1	7.2

Table SB3. Catch per unit effort (metric tons/day fished) from the directed butterfish fishery, 1982-1990.

Year	CPUE	Number of Directed trips
1982	19.86	608
1983	13.24	351
1984	24.92	802
1985	15.17	301
1986	16.47	189
1987	17.69	278
1988	5.15	87
1989	7.09	151
1990	7.07	85
Average	14.07	317

[1]Directed effort is defined as trips by vessels over 5 G.R.T. that land greater than 50% butterfish

Table SB4. Total mortality rates (Z) for butterfish derived from NEFC fall survey abundance indices (Table 3), 1968-1990.

	AGE			
Year	0/1	1/2	2/ 3	3/4
1968/69	.78	3.17	2.33	-
1969/70	1.26	3.09	3.05	-
1970/71	1.10	2.78	1.28	-
1971/72	3.22	3.34	2.64	-
1972/73	.97	1.72	1.49	-
1973/74	2.01	2.77	1.40	-
1974/75	1.54	2.23	2.45	-
1975/76	.01	2.11	1.65	-
1976/77	1.22	1.45	2.18	-
1977/78	1.79	1.17	1.78	-
1978/79	.61	.50	4.03	-
1979/80	1.06	1.36	1.88	1.50
1980/81	1.60	1.83	4.17	4.29
1981/82	2.20	2.30	4.52	.73
1982/83	.02	.89	.38	.69
1983/84	1.51	1.96	1.34	-
1984/85	1.14	1.86	1.58	3.43
1985/86	2.26	1.95	1.84	1.93
1986/87	1.49	1.42	3.89	-
1987/88	1.29	0.86	3.57	-
1988/89	1.73	0.36	2.55	-
1989/90	2.30	2.55	2.76	-
68/77 **MEAN**	1.39	2.38	2.03	
78/90 **MEAN**	1.43	1.49	2.71	

GULF OF MAINE COD

An updated analytical assessment of the Gulf of Maine cod stock for 1982-1990 was presented to the SARC (SAW/12/SARC/5). The assessment included estimates of abundance and fishing mortality rates from Virtual Population Analysis (VPA) tuned with the ADAPT method (Gavaris 1988). Two additional analyses were presented for SARC consideration of their applicability to the assessment. SAW/12/SARC/4 presented a preliminary analysis of cod discards from the Gulf of Maine shrimp fishery using data from NEFC sea sampling program. SAW/12/SARC/3 provides a statistical analysis of catch-per-unit effort data to obtain standardized effort indices for the cod fishery. Both of these analyses were recommended in the SARC review of the Georges Bank cod assessment (NEFC 1990).

The best assessment, agreed by the SARC, indicates that the fully recruited fishing mortality rate on this cod stock has been around 1.0 for the past decade, and is currently at that level. Above average recent recruitment and in particular a large 1987 year class has maintained catches at a high level. The stock is currently overexploited with respect to biological reference points based on this assessment. The assessment may be underestimating the fishing mortality rate and overestimating stock sizes because of major sources of uncertainty noted by the SARC.

Background

The Atlantic cod (Gadus morhua) in the Gulf of Maine (NAFO Division 5Y) has been commercially exploited since the 17th century. Statistics are available since 1893 and can be divided into four periods: (1) an early era from 1893-1915 in which record high landings (>17,000 tons) in 1895 and 1906 were followed by 10 years of reduced catches.; (2) a period from 1916-1940 in which annual landings were relatively stable, fluctuating between 5000 - 11500 tons and averaging 8300 MT per year: (3) a period from 1941-1963 when landing sharply increased (1945: 14,500 MT) and then rapidly decreased to a record low of 2600 tons in 1957: and (4) the period since 1964 during which landings have generally increased. Total landings doubled between 1964 and 1968, doubled again between 1968 and 1977, and averaged 12,200 tons per year during 1976-1985. Landings in 1990 reached 15,500 MT, the highest level since the early 1900s.

Data Sources

Table SC1 gives the commercial landings from this stock from 1960 through 1990. Virtually all of the landings in the recent time series are by the USA. Otter trawls are the principal gear (69% by weight in 1990) followed by gill nets (40% in 1987-89; 29% in 1990). Recreational catches are not accounted for in these data and are not included in the assessment; there is a need to investigate the level of recreational landings and incorporate them into future assessments.

Discards as a component of catch were not included in the assessment. SAW/12/SARC/4 evaluated three methods for estimating discards: two ratio expansions and multiple linear regression. The SARC commented on the high variability apparent in the estimates: the need for refinement and the inclusion of variance estimates was recommended. In addition, the SARC was concerned about sample size and the need for age composition data. These methods were judged preliminary, and the estimates were not recommended for incorporation into the assessment. The SARC recommended that work continue on these techniques, particularly the regression technique, so that discard estimates can be included in future assessments for cod and other groundfish stocks.

Monthly length frequency and age samples were pooled by calendar quarter. Quarterly mean weights by market category were obtained by applying the cod length-weight equation to the quarterly market category sample length frequencies. Quarterly age length keys were applied to numbers at length distributions by market category and summed to derive the annual catch-at-age matrix and mean weights-at-age in the catch (Table SC2). Mean weights in the stock based on survey data, adjusted to the beginning of the year, are presented in Table SC3.

Abundance indices are available from the NEFC groundfish survey (Table SC4) and the U. S. commercial catch-per-unit-effort (CPUE) data (Table SC5). Recent NEFC survey indices are among the highest observed in the time series, reflecting strong 1986 and 1987 year classes. The NEFC survey trawl doors were changed in 1985 to improve efficiency. The associated change in fishing power of the gear has not been thoroughly evaluated and was not incorporated into the assessment. The SARC noted this as an area of uncertainty in the assessment. The SARC also noted that age 0 and 1 cod are well represented in the Massachusetts Inshore Groundfish Survey catches. Incorporation of these data is advised.

Commercial abundance indices were derived based on all trips landing cod. SAW 11 recommended that a more rigorous analysis of commercial catch and effort data should be undertaken to compute standardized effort indices. SAW/12/SARC/3 uses the General Linear Modeling (GLM) technique to standardize CPUE indices. The results (Table SC6) track the observed series well and the model appears to be sensitive to the "directivity" shifts noted in SAW/12/SARC/5.

The rate of natural mortality was assumed to be 0.2 for all ages. Updated information on the maturity ogive for Gulf of Maine cod (O'Brien 1990) was incorporated in the yield and spawning biomass per recruit analysis and stock size projections given below.

Methodology

The ADAPT method (Gavaris 1988; Conser and Powers 1990) was used to obtain terminal year fishing mortality rates for VPA estimation of stock size and fishing mortality rates at age for 1982-1990. Separable VPA (Pope and Shepherd 1982) was used to obtain the fishing mortality rate on age 2 cod in 1990. The partial recruitment vector for this stock was judged to be flat topped from the ADAPT analysis and was calculated from the geometric mean of F over the years 1985-1989 for input in the yield per recruit analysis and projections.

Assessment Results

Fishing mortality rates remained high from 1982 through 1990 (Table SC7a). Estimates in 1990 are at essentially the same levels as in 1989 for all ages, reflecting current high fishing effort. Landings-at-age (Table SC2) shows the 1990 fishery was dominated by fish from the 1986 (age 4) and 1987 (age 3) year classes. Together these two cohorts accounted for 86% by number and 69% by weight of the landings, reflecting the dependency of the fishery on younger ages.

Population numbers at age (Table SC8b) show that prior to 1987, production of age 1 cod was fairly level, followed by high 1987 and 1988 age 1 cod production, then moderate production again in 1989. Cod from the high production years dominate the stock in 1990, with apparently poor age 1 recruitment in 1991. The ADAPT analysis shows that the coefficient of variation on these stock abundance figures for the fully recruited ages is of the order of 50% (Figure SC1).

Spawning stock biomass in 1990 was approximately 75% of that in 1989 and was dominated by age 3 cod produced in 1987. The time series of spawning stock biomass (both sexes) projected to the beginning of the spawning season is given below:

YR	1982	1983	1984	1985	1986	1987	1988	1989	1990
SSB	23440	18030	15296	13972	13006	13700	16124	24158	26222

Curves of Yield Per Recruit (YPR) and Spawning Stock Biomass per Recruit (SSB/R) are given in Figure SC2 using the input data given in Table SC9. Current F is at 0.94 and can be compared with the biological reference points $F_{20\%}$, F_{max}, and $F_{0.1}$ which are estimated at 0.40, 0.27, and 0.16, respectively. Substantial gains in yield and spawning stock biomass per recruit are indicated by reductions from the current F. Stock and recruitment data are plotted in Figure SC3.

SARC Analyses

The GLM analysis was reviewed by the SARC and it was determined that the appropriate model to use was that incorporating main effects of YEAR, TONNAGE, CLASS, AREA, and DEPTH. The year coefficients were used to compute relative effort in each year, 1982-90 (Table SC6). These results were then used along with spring and autumn survey indices in ADAPT to obtain the final assessment during the SARC.

Catch Projections

Catch projections were calculated using 1991 stock size estimates for ages 3 - 8 and age 2 recruitment estimates for the 1989 year class obtained from the calibration regression method available in RCRTINX2. Projections were made for fully recruited fishing mortality rates at the status quo level (0.94), $F_{20\%}$(0.40) and F_{max}(0.27), using expected recruitment plus and minus one standard error (Table SC8).

Major Sources of Uncertainty

o Discarding is generally thought to be an important source of fishing mortality on young cod. Discards are not included in the catch-at-age matrix with the effect that year class size will be overestimated and fishing mortality rates on younger ages will be underestimated in those years where high levels of discarding occurred.

o Recreational catch is a potentially important component of fishing mortality. It may comprise up to 15 percent of the total landings from the stock, but was not included in this analysis. Difficulties in including the recreational catch from the Marine Recreational Fishery Statistical Survey include sampling for age and size composition, and stock of origin of landings. The SARC noted that this is in general a major source of uncertainty for all species with a recreational component where estimates of these landings are not included in the catch-at-age matrix.

o Trawl door changes made in the NEFC survey have not been accounted for in the assessment. The change can have an effect on the cod survey indices from 1985 to the present, but the extent of the effect is currently unknown. The SARC recommends examination of this effect, perhaps through sensitivity runs of stock projections.

Recommendations

o Preliminary work presented on cod discards from the northern shrimp fisheries should be continued to refine estimation techniques and expanded to include all fisheries with cod discard. Sea sampling data inputs and collaboration with work being done by the SAW Sea Sampling Working Group is recommended. The SARC recommends that every attempt be made to incorporate discard mortality into future assessments for all New England groundfish stocks.

o The SARC recommends that recreational fishery data should be examined further to determine adequacy or shortcomings for assessment use; basic data tabulations of length, weight are advised. Inadequacies about stock origin of catch may be reduced by identification of the landings to the county level. Apportionment of these data into the catch for trial sensitivity runs may identify the direction of bias and prescribe the best course for use of these data in assessments. Future scientific advice will require analysis of the influence of recreational fisheries. Given the importance of this topic for the assessment of several stocks in the region, the SARC noted that discussion before the SAW Plenary and the Steering Committee is advisable. The SARC strongly recommends that every attempt be made to incorporate the recreational catch into future assessments.

- The SARC recommends that data on age 0 and 1 year old cod from the Massachusetts Inshore Groundfish Survey be incorporated into future assessments as additional indices of stock abundance or recruitment.

Table SC1. Commercial landings (metric tons[1] (live) of Atlantic cod from the Gulf of Maine (MAFO Division 5Y), 1960 - 1990.

	Gulf of Maine			
Year	USA	Canada	Other	Total
1960	3448	129	-	3577
1961	3216	18	-	3254
1962	2989	83	-	3072
1963	2595	3	133	2731
1964	3226	25	-	3251
1965	3780	148	-	3928
1966	4008	384	-	4392
1967	5676	297	-	5973
1968	6360	61	-	6421
1969	8157	59	268	8484
1970	7812	26	423	8261
1971	7380	119	163	7662
1972	6776	53	88	6917
1973	6069	68	9	6146
1974	7639	120	5	7764
1975	8903	86	26	9015
1976	10172	16	-	10188
1977	12426	-	-	12426
1978	12426	-	-	12426
1979	11680	-	-	11680
1980	13528	-	-	13528
1981	12534	-	-	12534
1982	13582	-	-	13582
1983	13981	-	-	13981
1984	10806	-	-	10806
1985	10693	-	-	10693
1986	9664	-	-	9664
1987	7527	-	-	7527
1988	7958	-	-	7958
1989	10397	-	-	10397
1990*	15145	-	-	15145

[1]USA landings from NMFS, NEFC Detailed Weighout Files and Canvass Data

*Provisional

Table SC2. Catch at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 1990.

Total Commercial Catch in Numbers (000's) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
1982	30	1380	1633	1143	633	69	91	61	41	4	33	5118
1983	-	866	2357	1058	638	422	47	61	23	9	15	5496
1984	4	446	1240	1500	437	194	74	19	15	11	17	3957
1985	-	407	1445	991	630	128	78	32	4	11	11	3737
1986	-	84	2164	813	250	177	39	24	20	4	8	3583
1987	2	216	595	1109	277	66	51	9	8	8	3	2344
1988	-	160	1443	953	406	43	9	17	1	2	1	3035
1989	-	337	1583	1454	449	81	35	6	3	5	7	3960
1990	-	205	3425	2064	430	157	27	30	10	15	17	6380

Total Commercial Catch in Weight (Tons) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
1982	24	1595	2717	3160	3019	461	813	608	531	41	613	13582
1983	-	1009	3913	2619	2410	2518	271	643	227	102	269	13981
1984	3	516	2071	4080	1607	1145	603	186	193	152	250	10816
1985	-	513	2523	2816	2814	705	615	363	51	141	152	10693
1986	-	110	3976	2375	1153	1072	296	243	253	54	132	9664
1987	2	283	1001	3641	1340	451	455	88	116	110	40	7527
1988	-	203	2715	2311	2097	295	85	191	11	36	14	7958
1989	-	420	2811	4351	1737	325	323	67	43	87	163	10397
1990	-	219	5794	4687	1834	1200	290	354	153	214	350	15095

Total Commercial Catch Mean Weight (kg) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
1982	0.801	1.156	1.664	2.764	4.770	6.739	8.944	9.931	12.922	10.618	18.456	2.654[a]
1983	-	1.164	1.660	2.475	3.778	5.962	5.808	10.522	10.089	10.898	17.813	2.544
1984	0.589	1.159	1.670	2.721	3.677	5.898	8.119	9.595	12.889	13.951	15.028	2.731
1985	-	1.260	1.746	2.840	4.466	5.525	7.901	11.218	11.420	13.386	14.523	2.861
1986	-	1.304	1.837	2.923	4.619	6.067	7.669	10.030	12.463	12.907	16.554	2.698
1987	1.028	1.313	1.684	3.283	4.831	6.824	8.878	10.023	13.752	14.738	14.596	3.212
1988	-	1.268	1.881	2.426	5.166	6.767	9.932	11.126	14.960	15.763	20.356	2.622
1989	-	1.247	1.776	2.993	3.864	4.872	9.267	11.938	14.806	18.196	21.521	2.626
1990	-	1.071	1.692	2.271	4.265	7.645	10.734	11.758	15.015	14.784	20.295	2.366

Total Commercial Catch Mean Length (cm) at Age

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
1982	43.2	48.3	53.8	63.4	76.8	86.1	94.6	97.9	107.4	101.0	120.7	59.9[b]
1983	-	48.6	53.8	61.4	70.8	82.4	80.5	98.8	97.5	100.0	118.7	59.8
1984	39.0	48.4	54.1	63.4	69.7	81.8	91.5	96.7	106.9	109.6	112.0	61.6
1985	-	49.8	55.1	64.6	74.9	80.3	90.8	101.9	103.1	108.2	109.7	62.8
1986	-	50.3	55.9	65.0	75.4	82.6	89.9	98.7	105.8	107.5	116.2	61.6
1987	47.0	50.4	54.4	67.8	76.9	86.5	93.8	98.7	109.5	111.7	111.3	65.4
1988	-	50.1	56.4	61.1	78.7	86.4	98.6	102.3	113.0	114.8	125.0	61.4
1989	-	49.8	55.5	65.7	71.5	76.7	95.8	103.4	112.6	120.4	126.8	61.7
1990	-	47.5	54.8	60.0	73.7	90.0	100.9	104.0	111.8	112.6	124.6	59.2

Table SC3. Mean weight at age (kg) at the beginning of the year (January 1) for Atlantic cod from the Gulf of Maine cod stock (NAFO Division 5Y), 1978 - 1990. Values derived from catch mean weight-at-data (mid-year) using procedures described by Rivard (1980).

	Age									
Year	1	2	3	4	5	6	7	8	9	10+ [a]
1982	0.664	0.965	1.364	2.364	(3.750)	(5.600)	(7.400)	9.853	(11.650)	16.000
1983	-	0.966	1.385	2.029	3.231	5.333	6.256	9.701	10.010	16.000
1984	0.403	0.944	1.394	2.125	3.017	4.720	6.957	(9.670)	11.646	16.000
1985	-	0.861	1.423	2.178	3.486	4.507	6.826	9.544	10.468	16.000
1986	-	1.147	1.521	2.259	3.622	5.205	6.509	8.902	11.824	16.000
1987	0.926	1.097	1.482	2.456	3.758	5.614	7.339	8.767	11.744	16.000
1988	-	1.142	1.572	2.021	4.118	5.718	8.233	9.939	12.245	16.000
1989	-	1.071	1.501	2.373	3.062	5.017	7.919	10.889	12.835	16.000
1990	-	(0.950)	1.453	2.008	3.573	5.435	7.232	10.438	13.388	16.000
Mean Values										
88-90	(0.664)	1.054	1.509	2.134	3.584	5.390	7.795	10.422	12.823	16.000
82-90	0.664	1.016	1.455	2.202	3.513	5.239	7.186	9.745	11.557	16.000

[a] Mean weight-at-age values for 10+ set equal to mean (1982-1990) catch (mid-year) weight at age value for 10+.

( ) Values in parentheses are modified from calculated values.

Table SC4a. Stratified mean catch per tow in numbers and weight (kg) for Atlantic cod in NEFC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine (Strata 26-30 and 36-40), 1963 - 1991. [a,b]

	Spring		Autumn	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	3.79	11.1
1964	-	-	2.57	14.1
1965	-	-	2.88	7.4
1966	-	-	2.43	8.0
1967	-	-	1.64	5.7
1968	3.49	11.1	2.81	12.0
1969	2.09	8.1	1.77	9.5
1970	1.41	6.8	3.14	10.1
1971	0.92	4.3	2.80	10.2
1972	1.32	5.0	5.97	8.0
1973	4.83	11.6	2.86	5.4
1974	1.86	4.6	2.78	5.5
1975	1.61	3.7	3.94	5.3
1976	1.78	4.7	1.38	4.2
1977	2.49	5.3	2.50	9.4
1978	1.32	4.8	4.67	11.9
1979	2.74	5.9	2.24	10.8
1980	1.74	5.7	5.71	13.1
1981	3.95	9.9	1.55	5.0
1982	3.04	7.9	4.98	9.9
1983	2.51	6.5	2.71	5.4
1984	2.18	3.6	1.55	5.4
1985	2.52	7.8	2.92	8.5
1986	1.96	3.6	1.95	5.1
1987	1.68	3.0	2.98	3.4
1988	3.13	3.3	5.90	6.6
1989	2.86	3.8	5.89	6.8
1990	2.99	4.6	3.78	7.3
1991	3.03	4.3		

[a] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences.

[b] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. No adjustments have been made to the catch per tow data for these gear differences.

Table SC4b. Stratified mean catch per tow at age (numbers) of Atlantic cod in NEFC offshore spring and autumn bottom trawl surveys in the Gulf of Maine, 1963 - 1991. [a,b,c,d]

Year	Age Group 0	1	2	3	4	5	6	7	8	9	10+	Totals 0+	1+	2+	3+	4+	5+
Spring																	
1968	0.082	0.393	0.791	0.902	0.542	0.345	0.133	0.083	0.071	0.038	0.106	3.486	3.404	3.011	2.220	1.318	0.776
1969	0.000	0.000	0.023	0.197	0.564	0.517	0.406	0.164	0.092	0.057	0.065	2.085	2.085	2.085	2.062	1.865	1.301
1970	0.000	0.102	0.079	0.035	0.060	0.175	0.299	0.394	0.048	0.038	0.184	1.414	1.414	1.312	1.233	1.198	1.138
1971	0.000	0.016	0.091	0.070	0.187	0.031	0.053	0.192	0.132	0.099	0.046	0.917	0.917	0.901	0.810	0.740	0.553
1972	0.000	0.226	0.098	0.333	0.126	0.128	0.023	0.068	0.065	0.147	0.105	1.319	1.319	1.093	0.995	0.662	0.536
1973	0.000	0.022	2.724	0.581	0.397	0.224	0.125	0.061	0.143	0.161	0.392	4.830	4.830	4.808	2.084	1.503	1.106
1974	0.000	0.305	0.036	0.871	0.211	0.142	0.073	0.031	0.031	0.013	0.149	1.862	1.862	1.557	1.521	0.650	0.439
1975	0.004	0.060	0.448	0.068	0.683	0.166	0.071	0.003	0.003	0.012	0.092	1.610	1.606	1.546	1.098	1.030	0.347
1976	0.000	0.027	0.195	0.672	0.098	0.575	0.055	0.069	0.042	0.000	0.047	1.780	1.780	1.753	1.558	0.886	0.788
1977	0.000	0.016	0.191	0.334	1.278	0.070	0.507	0.004	0.065	0.000	0.024	2.489	2.489	2.473	2.282	1.948	0.670
1978	0.000	0.022	0.067	0.183	0.223	0.491	0.048	0.205	0.005	0.068	0.005	1.317	1.317	1.295	1.228	1.045	0.822
1979	0.028	0.343	1.045	0.136	0.320	0.257	0.439	0.038	0.091	0.008	0.034	2.739	2.711	2.368	1.323	1.187	0.867
1980	0.057	0.057	0.357	0.278	0.100	0.339	0.194	0.246	0.000	0.105	0.011	1.744	1.687	1.630	1.273	0.995	0.895
1981	0.000	0.823	0.537	0.800	0.987	0.266	0.233	0.089	0.126	0.086	0.000	3.947	3.947	3.124	2.587	1.787	0.800
1982	0.012	0.273	0.827	0.419	0.563	0.701	0.095	0.088	0.000	0.034	0.032	3.044	3.032	2.759	1.932	1.513	0.950
1983	0.008	0.401	0.627	0.534	0.411	0.229	0.116	0.059	0.000	0.058	0.065	2.508	2.500	2.099	1.472	0.938	0.527
1984	0.000	0.097	0.662	0.735	0.475	0.122	0.034	0.037	0.019	0.000	0.000	2.181	2.181	2.084	1.422	0.687	0.212
1985	0.000	0.028	0.238	0.622	0.665	0.677	0.095	0.114	0.052	0.000	0.026	2.517	2.517	2.489	2.251	1.629	0.964
1986	0.000	0.417	0.330	0.647	0.387	0.074	0.046	0.027	0.011	0.000	0.018	1.957	1.957	1.540	1.210	0.563	0.176
1987	0.000	0.049	0.638	0.486	0.300	0.128	0.011	0.045	0.011	0.000	0.014	1.682	1.682	1.633	0.995	0.509	0.209
1988	0.029	0.663	1.053	0.633	0.355	0.217	0.087	0.063	0.000	0.027	0.000	3.127	3.098	2.435	1.382	0.749	0.394
1989	0.000	0.029	0.822	1.000	0.800	0.114	0.097	0.000	0.000	0.000	0.000	2.862	2.862	2.833	2.011	1.011	0.211
1990	0.000	0.000	0.241	1.680	0.794	0.211	0.041	0.023	0.000	0.000	0.000	2.990	2.990	2.990	2.749	1.069	0.275
1991												3.029					
Autumn																	
1963	0.032	0.416	0.865	0.803	0.544	0.371	0.344	0.192	0.117	0.061	0.048	3.793	3.761	3.345	2.480	1.677	1.133
1964	0.000	0.059	0.078	0.302	0.549	0.547	0.502	0.239	0.152	0.073	0.065	2.566	2.566	2.507	2.429	2.127	1.578
1965	0.001	0.545	0.564	0.528	0.481	0.318	0.240	0.109	0.051	0.028	0.016	2.881	2.880	2.335	1.771	1.243	0.762
1966	0.109	0.131	0.410	0.447	0.460	0.358	0.283	0.123	0.050	0.031	0.023	2.425	2.316	2.185	1.775	1.328	0.868
1967	0.008	0.083	0.138	0.368	0.430	0.246	0.172	0.104	0.045	0.026	0.022	1.642	1.634	1.551	1.413	1.045	0.615
1968	0.008	0.023	0.115	0.461	0.805	0.624	0.402	0.167	0.100	0.046	0.061	2.812	2.804	2.781	2.666	2.205	1.400
1969	0.010	0.038	0.079	0.227	0.404	0.354	0.299	0.141	0.093	0.083	0.040	1.768	1.758	1.720	1.641	1.414	1.010
1970	0.476	0.603	0.170	0.353	0.211	0.313	0.271	0.506	0.084	0.060	0.094	3.141	2.665	2.062	1.892	1.539	1.328
1971	0.863	0.114	0.153	0.135	0.383	0.295	0.278	0.163	0.204	0.128	0.082	2.798	1.935	1.821	1.668	1.533	1.150
1972	0.020	3.576	0.780	0.978	0.150	0.060	0.110	0.025	0.102	0.155	0.010	5.966	5.946	2.370	1.590	0.612	0.462
1973	0.408	0.210	1.393	0.089	0.325	0.136	0.050	0.018	0.033	0.108	0.087	2.857	2.449	2.239	0.846	0.757	0.432
1974	0.181	0.720	0.121	1.118	0.187	0.230	0.050	0.008	0.008	0.027	0.127	2.777	2.596	1.876	1.755	0.637	0.450
1975	0.030	0.094	1.966	0.086	1.510	0.163	0.070	0.011	0.002	0.002	0.008	3.942	3.912	3.818	1.852	1.766	0.256
1976	0.000	0.156	0.134	0.405	0.064	0.492	0.037	0.061	0.000	0.010	0.020	1.379	1.379	1.223	1.089	0.684	0.620
1977	0.000	0.018	0.291	0.446	0.937	0.123	0.481	0.031	0.079	0.018	0.078	2.502	2.502	2.484	2.193	1.747	0.810
1978	0.202	1.111	0.301	0.907	0.532	1.160	0.091	0.264	0.007	0.049	0.041	4.665	4.463	3.352	3.051	2.144	1.612
1979	0.003	0.236	0.381	0.104	0.536	0.251	0.501	0.033	0.138	0.000	0.053	2.236	2.233	1.997	1.616	1.512	0.976
1980	0.022	1.026	2.111	1.423	0.403	0.188	0.272	0.168	0.024	0.015	0.058	5.710	5.688	4.662	2.551	1.128	0.725
1981	0.008	0.397	0.245	0.352	0.304	0.057	0.076	0.024	0.069	0.000	0.018	1.550	1.542	1.145	0.900	0.548	0.244
1982	0.000	0.449	2.014	1.585	0.748	0.159	0.000	0.025	0.000	0.000	0.000	4.980	4.980	4.531	2.517	0.932	0.184
1983	0.029	1.064	0.626	0.546	0.089	0.169	0.126	0.000	0.000	0.000	0.058	2.707	2.678	1.614	0.988	0.442	0.353
1984	0.028	0.246	0.270	0.362	0.256	0.141	0.131	0.057	0.000	0.020	0.042	1.553	1.525	1.279	1.009	0.647	0.391
1985	0.266	0.378	0.910	0.763	0.209	0.218	0.074	0.000	0.034	0.021	0.049	2.922	2.656	2.278	1.368	0.605	0.396
1986	0.000	0.301	0.490	0.654	0.333	0.086	0.042	0.000	0.000	0.024	0.021	1.951	1.951	1.650	1.160	0.506	0.173
1987	0.138	0.599	1.324	0.600	0.257	0.061	0.000	0.000	0.000	0.000	0.000	2.979	2.841	2.242	0.918	0.318	0.061
1988	0.000	1.951	2.245	0.960	0.528	0.110	0.076	0.033	0.000	0.000	0.000	5.903	5.903	3.952	1.707	0.747	0.219
1989	0.000	0.526	3.026	1.717	0.372	0.220	0.018	0.000	0.000	0.011	0.000	5.890	5.890	5.364	2.338	0.621	0.249
1990	0.008	0.037	0.464	2.080	0.788	0.352	0.036	0.013	0.000	0.000	0.000	3.778	3.770	3.733	3.269	1.189	0.401
1991																	

[a] Spring and autumn: Strata 26-30 and 36-40. [b] Catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey. [c] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences. [d] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. No adjustments have been made to the catch per tow data for these gear differences.

Table SC5. USA commercial landings (L)[1], days fished (DF)[2], and landings per day fished (L/DF), by vessel tonnage class (Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT), of Atlantic cod for otter trawl trips catching cod from the Gulf of Maine (NAFO Division 5Y), 1965 - 1990.

	Class 2			Class 3			Class 4			Totals	
Year	L	DF	L/DF	L	DF	L/DF	L	DF	L/DF	L	L/DF[3]
							ALL TRIPS LANDING COD				
1965	1412	2691	0.52	935	965	0.97	46	92	0.50	2393	0.70
1966	1265	2379	0.53	1093	938	1.17	113	83	1.36	2471	0.85
1967	1790	2175	0.82	2341	1232	1.90	108	196	0.55	4239	1.41
1968	1839	2696	0.68	1955	1266	1.54	219	182	1.20	4013	1.13
1969	2992	3301	0.91	2874	1497	1.92	549	337	1.63	6415	1.42
1970	3359	4834	0.69	2010	1666	1.21	389	425	0.92	5758	0.89
1971	2917	4000	0.73	1727	1475	1.17	293	422	0.69	4937	0.88
1972	2190	4104	0.53	1463	1637	0.89	192	244	0.79	3845	0.68
1973	2018	3915	0.52	1172	1430	0.82	194	252	0.77	3384	0.64
1974	2292	3954	0.58	2108	1455	1.45	458	367	1.25	4858	1.02
1975	3108	4423	0.70	2599	1818	1.43	311	373	0.83	6018	1.02
1976	3168	4404	0.72	3143	2096	1.50	262	527	0.50	6573	1.08
1977	3816	4354	0.88	3903	2448	1.59	341	631	0.54	8060	1.21
1978	3859	5063	0.76	3334	2618	1.27	489	809	0.60	7682	0.97
1979	3731	5623	0.66	3169	2425	1.31	475	779	0.61	7375	0.94
1980	3967	6252	0.63	3497	3181	1.10	571	908	0.63	8035	0.83
1981	3722	4912	0.76	3253	3277	0.99	737	986	0.75	7712	0.86
1982	3619	6086	0.59	4466	4343	1.03	1281	1448	0.88	9366	0.84
1983	3473	5512	0.63	4874	4731	1.03	1326	1782	0.74	9673	0.85
1984	2188	5444	0.40	3217	5042	0.64	883	1668	0.53	6288	0.54
1985	1801	4890	0.37	3457	5921	0.58	1515	2675	0.57	6773	0.52
1986	1638	4721	0.35	3088	6149	0.50	1513	2990	0.51	6239	0.46
1987	1131	4782	0.24	2005	6417	0.31	1012	2724	0.37	4148	0.31
1988	1327	5089	0.26	2137	5446	0.39	830	2105	0.39	4294	0.35
1989	1559	4060	0.38	2885	4969	0.58	1334	1882	0.71	5778	0.56
1990	2004	4282	0.47	4749	5351	0.89	3212	2029	1.58	9965	1.03

[1]Metric tons, live weight.

[2]Days fished with trawl on bottom; derived by dividing hours fished with trawl on bottom by 24.

[3]Total L/DF was derived by weighting individual tonnage class L/DF values by the percentage of total landings accounted for by each vessel class and summing over the three vessel class categories.

Table SC6. General Linear Model (GLM) results for Gulf of Maine Cod Effort (DAYS) Standardization. STANDARD - YR 82: MONTH 11: TC 25: AREA 514: DEPTH 3

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LOG CATCH PER DAY FISHING (MT/DAY)

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	24	8802.86132395	366.78588850	230.23	0.0	0.198537	19.4406
ERROR	22306	35535.78046951	1.59310412		ROOT MSE		LCPE MEAN
CORRECTED TOTAL	22330	44338.64179345			1.26218228		6.49250933

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF
YR	8	3753.45385608	294.51	0.0	8
TC2	8	2591.31184044	203.32	0.0	8
AREA	4	661.46016113	103.80	0.0	4
DEPTH	4	1796.63546630	281.94	0.0	4

RELATIVE EFFORT COMPUTED BY DIVIDING RETRANSFORMED YEAR COEFFICIENTS INTO ANNUAL CATCH ESTIMATES:

YEAR	EFFORT
1982	13582
1983	13899
1984	15215
1985	19112
1986	20444
1987	25123
1988	24064
1989	20539
1990	21617

Table SC7. Estimates of instaneous fishing mortality (F), beginning year stock size (000s of fish), and mean stock biomass (000s of tons) for Gulf of Maine cod as estimated from virtual population analysis (VPA), calibrated using the ADAPT procedure, 1982-1990.

(a) Fishing Mortality

■	1982	1983	1984	1985	1986	1987	1988	1989	1990
1 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
2 ■	0.1829	0.2135	0.1130	0.0735	0.0235	0.0413	0.0212	0.0243	0.0424
3 ■	0.5345	0.5426	0.5381	0.6417	0.6835	0.2298	0.4217	0.2991	0.3634
4 ■	0.6400	0.8191	0.8211	1.1899	0.9630	0.9517	0.7041	1.0372	0.8102
5 ■	0.6416	0.9446	1.0214	1.0585	1.2193	1.1209	1.2416	0.8871	1.0727
6 ■	0.5522	1.3182	0.8765	1.0100	1.0381	1.4653	0.4976	0.9155	0.9415
7 ■	0.6477	0.9500	0.8822	1.1672	1.0488	1.0267	0.8084	1.0246	0.9415
8 ■	0.6477	0.9500	0.8822	1.1672	1.0488	1.0267	0.8084	1.0246	0.9415
Mean F (unweighted)									
2+■	0.5495	0.8197	0.7335	0.9011	0.8607	0.8375	0.6433	0.7446	0.7304
3+■	0.6106	0.9207	0.8369	1.0391	1.0002	0.9702	0.7470	0.8647	0.8451
4+■	0.6258	0.9964	0.8967	1.1185	1.0636	1.1183	0.8120	0.9778	0.9415
5+■	0.6223	1.0407	0.9156	1.1007	1.0887	1.1599	0.8390	0.9630	0.9743
6+■	0.6159	1.0727	0.8803	1.1148	1.0452	1.1729	0.7048	0.9882	0.9415
Mean F (weighted by stock numbers)									
2+■	0.3871	0.5432	0.4935	0.4773	0.5165	0.3112	0.2812	0.2305	0.4006
3+■	0.5891	0.7014	0.7235	0.8747	0.7931	0.5818	0.5728	0.5403	0.5110
4+■	0.6381	0.9391	0.8642	1.1298	1.0224	1.0024	0.8148	0.9964	0.8575
5+■	0.6357	1.0604	0.9570	1.0670	1.1232	1.1500	1.0988	0.9031	1.0215
6+■	0.6235	1.2068	0.8788	1.0875	1.0418	1.2076	0.5996	0.9582	0.9415

(b) Stock Numbers (Jan 1) in thousands of fish.

■	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1 ■	6081.8	5632.4	7754.8	4891.1	7206.2	10311.7	18986.1	6671.0	11.7	0.0
2 ■	9122.6	4979.3	4611.5	6349.1	4004.5	5899.9	8442.5	15544.5	5461.8	9.6
3 ■	4358.8	6220.2	3293.1	3372.0	4830.0	3202.6	4635.0	6767.4	12421.9	4286.2
4 ■	2672.3	2091.1	2960.0	1574.2	1453.3	1996.4	2083.7	2489.1	4108.3	7071.1
5 ■	1477.4	1153.7	754.7	1066.2	392.1	454.2	631.0	843.7	722.3	1496.0
6 ■	179.7	636.8	367.3	222.5	302.9	94.9	121.2	149.3	284.5	202.3
7 ■	211.0	84.7	139.5	125.2	66.3	87.8	17.9	60.3	48.9	90.8
8 ■	318.3	191.3	115.0	91.2	93.5	47.3	41.2	35.5	128.3	56.6
1+■	24421	20990	19996	17691	18349	22095	34959	32561	23188	13213
2+■	18340	15357	12241	12800	11143	11783	15973	25890	23176	13213
3+■	9217	10378	7630	6451	7138	5883	7530	10345	17714	13203
4+■	4859	4158	4337	3079	2308	2681	2895	3578	5292	8917
5+■	2186	2067	1377	1505	855	684	811	1089	1184	1846
6+■	709	913	622	439	463	230	180	245	462	350

(c) Mean Biomass in thousands of tons.

■	1982	1983	1984	1985	1986	1987	1988	1989	1990
1 ■	4960.96	4594.45	6325.71	3989.74	5878.17	8411.41	15487.21	5441.62	9.58
2 ■	8761.34	4747.14	4588.99	6999.25	4679.59	6882.82	9603.98	17364.33	5194.64
3 ■	5137.39	7287.73	3889.24	3980.18	5891.63	4383.78	6492.48	9462.02	16068.16
4 ■	4997.13	3245.54	5046.60	2415.36	2510.89	3891.86	3327.27	4274.13	5872.60
5 ■	4764.40	2595.70	1602.21	2708.71	967.52	1217.79	1726.39	1987.58	1742.59
6 ■	851.19	1952.85	1326.48	712.99	1053.88	315.18	590.56	438.27	1296.81
7 ■	1272.26	292.34	692.11	538.99	290.57	449.18	112.24	322.43	313.13
8 ■	2760.83	1302.96	889.28	609.74	642.20	352.47	316.66	349.10	1136.18
1+■	33505.50	26018.72	24360.62	21954.96	21914.44	25904.50	37656.80	39639.48	31633.69
2+■	28544.54	21424.26	18034.90	17965.22	16036.26	17493.09	22169.59	34197.86	31624.11
3+■	19783.20	16677.12	13445.91	10965.97	11356.68	10610.27	12565.61	16833.53	26429.47
4+■	14645.81	9389.39	9556.68	6985.78	5465.05	6226.48	6073.12	7371.50	10361.31
5+■	9648.68	6143.85	4510.08	4570.43	2954.17	2334.63	2745.85	3097.38	4488.71
6+■	4884.28	3548.15	2907.87	1861.72	1986.65	1116.83	1019.46	1109.80	2746.12

Table SC8. Landings and Spawning Stock Biomass (MT) Projections for Atlantic cod in the Gulf of Maine. Recruitment is in 1000s of fish.

	1991(F=F90)			1992			199
Recruitment	F	Land.	SSB	F	Land.	SSB	SSB
LOW=3100	0.94	17614	29567	F90 =0.94	13085	21930	16238
	0.94	17614	29567	F20%=0.40	6905	21930	23077
	0.94	17614	29567	F0.1=0.27	4925	21930	25298
MID=4500	0.94	17614	29567	F90 =0.94	13085	21930	16238
	0.94	17614	29567	F20%=0.40	6905	21930	23077
	0.94	17614	29567	F0.1=0.27	4925	21930	25298
HIGH=6500	0.94	17724	31359	F90 =0.94	14612	27144	24521
	0.94	17724	31359	F20%=0.40	7620	27144	32190
	0.94	17724	31359	F0.1=0.27	5420	27144	34638

Table SC9. Input parameters for Gulf of Maine Cod Yield and Spawning Stock Biomass Per Recruit Analysis.

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Stock	Average Weights Catch
2	.0323	1.0000	.5000	1.054	1.195
3	.4143	1.0000	.8400	1.509	1.783
4	.9478	1.0000	.9600	2.134	2.563
5	1.0000	1.0000	1.0000	3.584	4.432
6	1.0000	1.0000	1.0000	5.390	6.428
7	1.0000	1.0000	1.0000	7.795	9.978
8+	1.0000	1.0000	1.0000	15.000	15.000

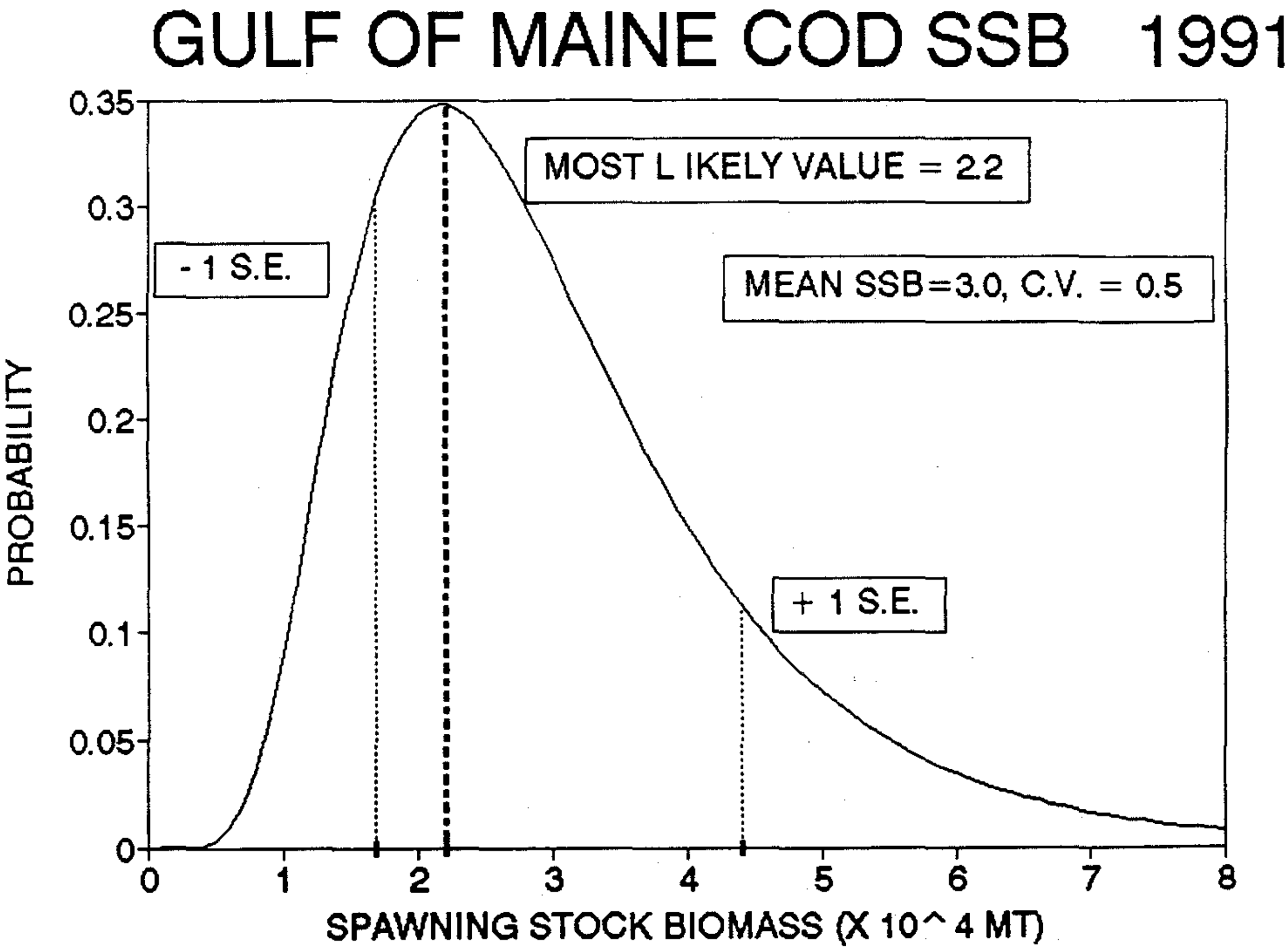


Figure SC1. Uncertainty plot for 1991 spawning biomass of Gulf of Maine cod assuming the estimates are lognormally distributed with a 50% coefficient of variation.

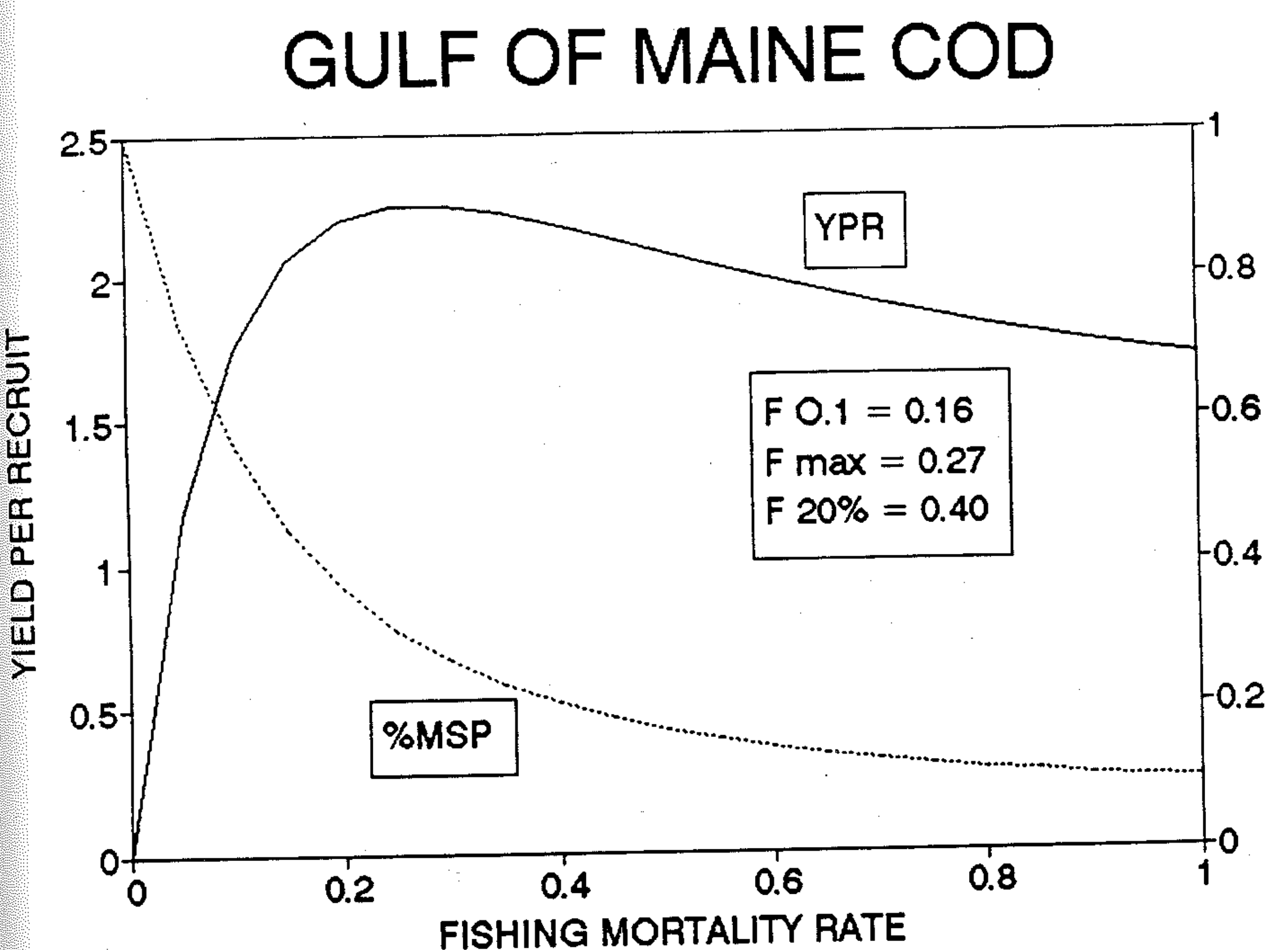


Figure SC2. Yield and spawning biomass per recruit as a percent of the maximum for Gulf of Maine cod.

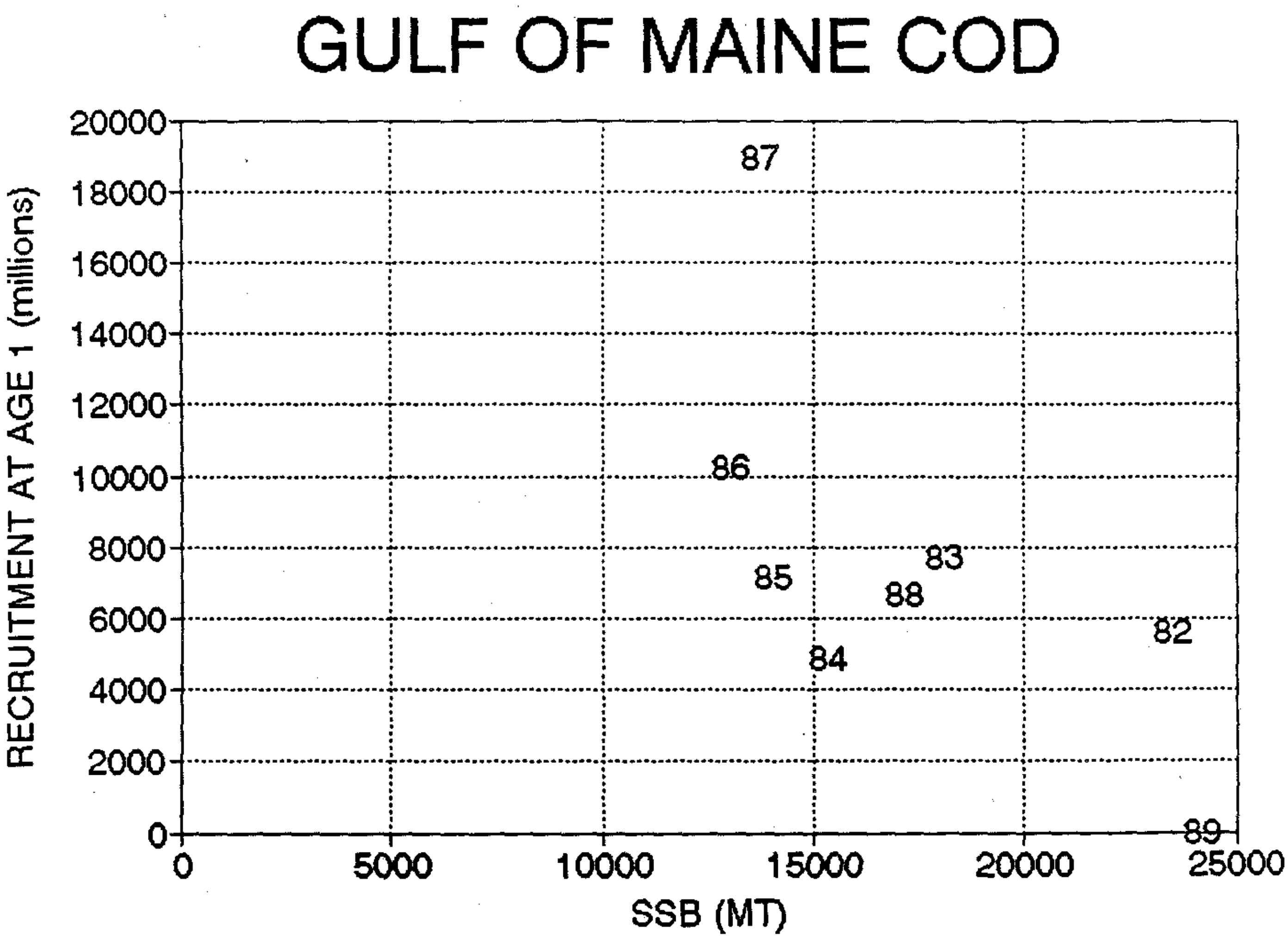


Figure SC3. Stock recruitment data for Gulf of Maine cod. The numbers labelling the datapoints are the year class for each cohort.

YELLOWTAIL FLOUNDER

Analytical assessments of Southern New England and Georges Bank stocks of yellowtail flounder were presented to the SARC (SAW/12/SARC/12). The assessments were based on updated information for the time series 1973-1990. Age-specific fishing mortality rates and stock sizes were estimated using ADAPT and revised biological reference points for the stocks were calculated. Improvements in methods for estimating discard mortality at age resulted in higher estimates of this source of mortality than in previous assessments.

For both the Southern New England and Georges Bank stocks, the SARC concluded that recent fishing mortality rates were well in excess of standard biological reference points ($F_{0.1}$, F_{max}, F_{med}) and that spawning stock biomass per recruit levels were below the threshold resulting in a long term level of 20% MSP. The SARC concluded that prospects for short-term (1992) future yields are not optimistic since recent landings have been dominated by the 1987 year class, which is expected to be largely fished out in 1991.

The SARC consensus view is that yields from the current yellowtail stocks depend on the strength of incoming year classes and that under current fishing patterns, high variability in annual yield can be expected due to variability of year-class strength. Recruitment is not expected to increase in the near term. Current fishing pressure is expected to result in spawning potentials ,10% of maximum. Reductions in current fishing mortality rates on the order of 70% will be required to attain the minimum conservation level of $F_{20\%MSP}$ defined in the multispecies FMP.

Background

For assessment purposes, two major stocks of yellowtail flounder (Limando ferruginea) are considered: Southern New England (SNE) and Georges Bank (GB). This species is fished in the northern Gulf of Maine, the Mid-Atlantic Bight and on the Grand Banks of Newfoundland primarily by otter trawl in all areas. Each of the areas are considered to contain separate stocks of yellowtail and the two areas considered here were treated separately.

The resource in both areas is managed under the New England Fishery Management Council's Multispecies FMP. Recent landings have increased to 8000 MT from SNE and 2700 MT from GB in 1990 due to the recruitment of a strong 1987 year class into the fishery.

Data Sources

Commercial landings from SNE and GB for the years 1960-1990 were derived from the NEFC commercial landings files (Table SD1). Commercial landings from GB have been 3,000 mt per year or less since 1985 while landings from this stock between 1962 and 1977 averaged 13,500 mt per year, with a peak of 18,300 mt in 1969. Landings from GB in 1990

2343 2,700 mt, a 245% increase from 1989 landings of 1,100 mt, the lowest commercial yield from this stock since at least 1960.

Commercial landings from SNE have varied considerably between 1960 and 1990, inter-annual variability in commercial landings has been greater since the mid-1970s than in the 1960s. Between 1963 and 1970, annual commercial landings averaged 24,000 mt, with a peak of 37,400 MT in 1969. Commercial landings declined from 19,800 MT in 1970 to 1,600 MT in 1976. Annual commercial landings were 6,000 mt or less from 1977-1981, increased rapidly to 17,000 MT in 1983, and then declined rapidly to a low of 900 mt in 1988. Commercial landings in 1990 (8,000 MT) showed a dramatic increase relative to landings of 2,500 MT in 1988.

Discards from the commercial fleet were estimated using three data sources: port sampling interviews, the NEFC groundfish survey results compared to the commercial landings, and the sea sampling data (SAW/12/SARC/12). The size/age distribution of unmeasured discards were assumed equal to the under-represented fraction of the NEFC groundfish survey distribution data for similar years and areas. In cases where sea sampling data were available (1989-1990), these direct observations were used in estimation. If there was no direct measure of discards, port sampling interviews were used and if neither of the former were available, the survey to landings comparison gave estimates of discard levels. Estimates of quarterly discards-at-age were smoothed by fitting a logistic retention rate model by nonlinear least squares. The smoothed retention rate estimates were used in estimating discard catch-at-age. By these methods, the age of discarded fish ranged from 1-4 with the highest proportion at age 2. Examination of the residuals from the logistic regressions suggest that there is no consistent bias introduced by using one discard estimation method versus another. The estimated proportions of discarded fish in each cohort over time is given in Figure SD1. It is evident in these graphs that discards at age 3 in 1990 were anomalously high probably due to changes in the minimum size and the presence of the strong 1987 year class.

Sufficient age samples were available for constructing the catch-at-age matrix for the period 1973-1990. The updated commercial landings data were matched to updated biostatistical samples at the greatest temporal resolution available in the data. The commercial landed catch was generally sized with monthly data, although a minor proportion of the landings were matched to samples from neighboring months. Quarterly age-length keys by market category were applied to the catch. Estimates of discards-at-age were constructed as described above. The uncertainty in discards-at-age is greater than in the landed catch-at-age. However, it is not currently possible to quantify this uncertainty. Catch-at-age for the SNE and GB stocks of yellowtail flounder used in the assessments are given in Table SD2. For assessment purposes, ages 1-6 and a 7+ grouping were used in subsequent analyses.

Mean weight at age from the catch is shown in Table SD3. For yield and spawning biomass per recruit calculations, two mean weight at age vectors were used: one accounting for estimated discard mortality, and the other representing estimated average weight at age without discards. These are shown in the following discussions.

Age-specific stratified mean catch rates in numbers and weight per tow from the autumn bottom trawl surveys from 1963-1990 (Table SD4a), from the spring offshore bottom trawl surveys from 1968-1990 (Table SD4b), and from the summer scallop survey from 1982-1990 (Table SD4c) were available for the SNE and GB stock assessments as indices of relative abundance.

Survey results from 1973-1990, when available, were used in the ADAPT analysis. The SARC discussed the potential effects of gear change on the survey indices. Previous gear comparisons designed to test the effect of net change on estimates of the abundance indices (Byrne and Forrester 1987) demonstrated no significant difference due to net change on yellowtail catch rates. The effect of trawl door change in 1985 on survey catch rates has not been thoroughly examined, although the available information suggests that this effect may be minor relative to other sources of variability in the survey indices for this species. The SARC examined residuals patterns from the ADAPT tuning and found no consistent pattern indicating a potential effect of the door change on the survey results for yellowtail. The SARC noted that the variance of the survey results for yellowtail was generally larger than for other demersal species, which is suspected to relate to the relative inefficiency of the survey gear for flounders.

Methodology

The ADAPT method of tuning was applied to yellowtail was the ADAPT method of tuning (Gavaris 1988, Conser and Powers 1990). The indices used for tuning the analysis were weighted in proportion to the inverse of the variance of each survey index. Natural mortality rate was assumed constant and equal to 0.2. Input partial recruitment was estimated via SVPA. The analyses presented in SAW/12/SARC/12 were structured to estimate the fishing mortality rates on ages 1, 2 and an age 3+ group on 1 January 1990. After review of the analyses presented, the SARC recommended several additional assessment runs, as specified below under SARC Analyses.

For the SNE spawning stock calculation, updated estimates of the maturity schedule for yellowtail (O'Brien M.S.) were used. The proportion of females mature at age was .13, .74, .98, and 1.0 for ages 1, 2, 3, and 4+. For GB, the age-specific proportions were 0, .88, and 1.0 for ages 1, 2, and 3+.

Assessment Results

For the final SNE analysis, the fully recruited fishing mortality rate (ages 3+, weighted by estimated stock size) was 1.61 (Table SD5). Fully recruited F has fluctuated without apparent trend over the last decade, ranging between .59 and 1.98, with a geometric mean of 1.29. The estimated age 2+ stock size on 1 January 1991 was 12 million fish (Table

SD5). This estimate has an approximate CV of 60%. For comparison, the age 2+ stock size point estimates for 1989 and 1990 were 96 and 59 million fish, respectively. Stock size estimates declined from 1980 until 1987 then increased with the recruitment of the 1987 year-class. Relatively strong year classes were estimated in 1987 and 1980. The 1990 SSB point estimate was 5.2 thousand MT, a 46% decline from the estimated 9.5 thousand mt SSB in 1989. Peak SSB in the time series occurred in 1982, with an estimated 10.6 thousand MT. The time series of mean spawning stock size (1000s MT) is given below:

	SNE	GB		SNE	GB
1973 -	13.89	24.51	1982 -	21.18	15.81
1974 -	8.75	17.27	1983 -	15.89	10.94
1975 -	3.93	11.54	1984 -	5.17	3.30
1976 -	4.66	12.92	1985 -	3.14	2.48
1977 -	4.76	8.88	1986 -	2.90	3.51
1978 -	8.69	6.44	1987 -	1.49	2.46
1979 -	9.75	11.19	1988 -	5.22	2.64
1980 -	8.78	12.42	1989 -	19.08	7.57
1981 -	10.52	12.02	1990 -	10.31	5.35

For the final GB analysis, the fully recruited fishing mortality rate (ages 3+, weighted by estimated stock size) was 1.12 (Table D6). Estimates of fully recruited F have generally been greater than 0.8 throughout the available time series, except for 1989 (F = 0.52), and have ranged to 2.11. The geometric mean fully recruited fishing mortality rate over the last decade was 0.98. The estimated total stock size on 1 January 1991 was 7 million fish (Table SD7), with an approximate CV of 0.6. Generally, stock size has declined over the time series. The current estimate is 70% lower than the average for 1989-90. Relatively strong year-classes were observed in 1973, 1974, 1977, 1980 and 1987; however, the estimated 1987 year-class strength was approximately 50% of the 1980, 1977 and 1974 classes. The 1990 SSB was estimated to equal 2.7 thousand MT, a 29% decline from the 1989 estimate, and a 70% decline from the 1970-1975 average.

SARC Analyses

The SARC suggested several modifications to the ADAPT analysis. These were run during the meeting and will be incorporated into the working paper.

The SARC updated YPR and SSBR analyses considering the effects of discard and landed catch mortality. The PR used for examining YPR and SSBR for the current fishing pattern, including estimates of discard mortality, were calculated as the geometric mean of partial recruitments from 1985 through 1989, assuming full recruitment at age 3 and a weight-at-age vector calculated as the average of the spring and fall surveys (Table SD7). The PR used for evaluating the current landed catch fishing mortality pattern (assuming no discard mortality) was derived by multiplying the above PR by the fraction of each age landed average over the years 1985-1989 (Table SD7). The mean weight at age applied was the estimated weight at age from commercial landings (Table SD8). Figure SD2 gives yield and spawning stock biomass per recruit curves with and without discarding for these stocks. Figure SD3 shows the patterns of stock and recruitment.

Current Reference Points

	F_{sq}	$F_{0.1}$	F_{max}	$F_{20\%}$
SNE	1.61	0.22	0.48	0.49
GB	0.82	0.25	0.63	0.58

For SNE, the point estimate of current fully recruited F (age 3+ in 1990) is 7.3 times the $F_{0.1}$ reference point and 3.3 times the F_{max} and $F_{20\%}$ reference points resulting from the current fishing mortality pattern.

For GB, the point estimate of current fully recruited F (age 3+ in ;1990) is 3.3 times the $F_{0.1}$ reference point, 1.3 times the F_{max} and 1.4 times the $F_{20\%}$ reference points resulting from the current fishing mortality pattern.

Catch Projections

Short-term projections (through 1992) are based on the geometric mean recruitment from 1980-1989 and a partial recruitment pattern calculated as the geometric mean of partial recruitments from 1985 through 1989, assuming full recruitment at age 3 and including discard mortality. To estimate recruitment in 1991, the RCRTINX2 program, which calibrates survey indices to VPA estimates of recruitment and then uses the calibration to predict the most recent recruitment point where the survey is available, was used. Three levels of recruitment were considered in projections; the median estimate was obtained from RCRTINX2, plus high and low recruitment estimates were taken as ± 1 standard error from the median estimate. The resulting projections are given in Table SD8a for SNE and Table SD8b for GB.

Major Sources of Uncertainty

There is inherent uncertainty in the stock size estimates from the ADAPT procedure. This uncertainty is expressed in Figure SD4 for both areas by assuming the estimates of spawning stock biomass are log normally distributed using the estimated CV of 60% from the ADAPT results. The major sources of uncertainty identified by the SARC were:

- Discards -- More complete analysis of the discard estimates is needed to determine possible sources of bias and the level of the precision. Additional sea sampling data will be required to reduce the level of uncertainty in these estimates.

- Terminal year estimates of fishing mortality rates are relatively imprecise. Note, however, that the values are so far above the reference points for both stocks that this imprecision does not affect the advice for these resources.

- Because this fishery is almost entirely dependent on incoming recruitment in each year, catch projections are inherently uncertain. They can only be as good as projections of future recruitment since there is little accumulated stock on which to fish.

Recommendations

- Augment sea sampling for discards and investigate the precision of the estimates.

- Develop a survey designed for sampling flatfish, probably during the winter. Examine the possibility of post stratification of the survey to improve the relative abundance estimates.

- Encourage the use of a variety of data for estimating discard levels for other species and stocks as was done in this assessment.

Table SD1. Commercial landings of yellowtail flounder (1000s MT) from 1960-1990.

Year	Southern NE Landings	Georges Bank Landings
1960	8.3	4.4
1961	12.3	4.2
1962	13.3	7.7
1963	22.3	11.0
1964	19.5	14.9
1965	19.4	14.2
1966	17.6	11.3
1967	15.3	8.4
1968	18.2	12.8
1969	15.6	15.9
1970	15.2	15.5
1971	8.6	11.9
1972	8.5	14.2
1973	7.2	15.9
1974	6.4	14.6
1975	3.2	13.2
1976	1.6	11.3
1977	2.8	9.4
1978	2.3	4.5
1979	5.3	5.5
1980	6.0	6.5
1981	4.7	6.2
1982	10.3	10.6
1983	17.0	11.3
1984	7.9	5.8
1985	2.7	2.5
1986	3.3	3.0
1987	1.6	2.7
1988	0.9	1.9
1989	2.5	1.1
1990	8.0	2.7

Table SD2. Catch at age matrices.

CATCH AT AGE INCLUDING DISCARDS (millions) - SOUTHERN NEW ENGLAND

Year

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.188	0.858	8.840	0.214	5.442	8.698	0.204	0.987	0.038	0.170	2.526	0.511	1.698	0.381	1.238
2	5.056	28.333	3.777	6.600	4.770	13.310	19.224	9.998	6.745	35.130	18.430	5.731	4.051	10.942	3.198
3	8.300	4.716	1.497	0.911	3.972	1.494	8.371	6.341	6.736	13.693	38.615	14.842	1.496	2.883	2.092
4	4.673	5.098	0.984	0.246	0.392	1.025	1.031	3.618	2.448	1.745	3.364	6.661	1.323	0.561	0.803
5	1.716	2.501	1.257	0.337	0.205	0.165	0.427	0.472	0.884	0.405	0.376	0.740	0.774	0.324	0.139
6	1.515	0.950	0.550	0.391	0.253	0.034	0.096	0.117	0.129	0.078	0.129	0.244	0.136	0.119	0.047
7	0.313	1.217	0.472	0.354	0.284	0.071	0.024	0.031	0.014	0.007	0.042	0.020	0.031	0.022	0.008
1+	21.762	43.672	17.378	9.052	15.319	24.796	29.377	21.563	16.994	51.227	63.481	28.749	9.510	15.232	7.525

Age	1988	1989	1990
1	5.899	0.000	0.130
2	1.981	24.321	0.775
3	0.509	1.294	38.771
4	0.407	0.279	1.352
5	0.100	0.042	0.068
6	0.017	0.003	0.005
7	0.006	0.000	0.000
1+	8.918	25.939	41.102

CATCH AT AGE INCLUDING DISCARDS (millions) - GEORGE'S BANK

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.347	5.425	2.590	0.515	0.330	9.659	0.251	0.309	0.035	0.922	2.178	0.356	2.300	0.270	0.041
2	9.009	12.672	22.674	24.352	6.742	2.248	9.879	5.695	2.228	14.000	7.732	1.914	3.334	5.955	1.819
3	13.545	8.052	6.997	5.087	9.844	3.971	3.396	8.707	5.946	7.061	16.027	4.266	0.815	0.979	2.729
4	9.277	7.398	3.392	1.347	1.721	1.660	1.243	1.419	4.555	3.267	2.317	4.735	0.652	0.348	0.762
5	3.743	3.544	2.084	0.533	0.395	0.460	0.551	0.320	0.796	1.031	0.625	1.591	0.410	0.161	0.131
6	1.259	0.851	0.670	0.432	0.221	0.102	0.140	0.085	0.122	0.061	0.108	0.257	0.060	0.051	0.039
7	0.360	0.625	0.479	0.435	0.255	0.072	0.130	0.014	0.004	0.022	0.018	0.064	0.005	0.023	0.072
1+	37.540	38.566	38.886	32.701	19.507	18.171	15.588	16.548	13.685	26.365	29.005	13.182	7.577	7.787	5.593

Age	1988	1989	1990
1	0.000	1.151	0.000
2	2.154	2.378	2.592
3	1.181	0.683	9.528
4	0.624	0.262	0.741
5	0.166	0.068	0.105
6	0.015	0.012	0.017
7	0.023	0.008	0.003
1+	4.162	4.561	12.985

Table SD3. Weight at age matrices.

WT AT AGE (MID-YR) in kg. - SOUTHERN NEW ENGLAND

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.210	0.203	0.218	0.228	0.215	0.234	0.189	0.206	0.140	0.226	0.175	0.182	0.183	0.186	0.247	0.270	0.311	0.301
2	0.298	0.308	0.290	0.303	0.284	0.296	0.301	0.281	0.262	0.263	0.262	0.239	0.264	0.285	0.268	0.293	0.337	0.327
3	0.381	0.359	0.385	0.427	0.385	0.402	0.366	0.384	0.343	0.354	0.341	0.298	0.370	0.335	0.361	0.398	0.389	0.378
4	0.420	0.429	0.439	0.528	0.521	0.543	0.476	0.499	0.484	0.502	0.499	0.388	0.428	0.470	0.412	0.501	0.546	0.461
5	0.430	0.477	0.436	0.533	0.529	0.710	0.590	0.690	0.619	0.661	0.671	0.497	0.541	0.598	0.542	0.664	0.736	0.800
6	0.506	0.476	0.469	0.568	0.484	0.791	0.684	0.891	0.664	0.821	0.829	0.652	0.620	0.617	0.595	0.936	0.959	0.884
7	0.611	0.518	0.515	0.603	0.612	0.677	0.679	1.182	0.476	0.956	0.838	0.724	0.867	0.804	0.905	0.937	1.278	0.781

WT AT AGE (JAN 1) in kg. - SOUTHERN NEW ENGLAND

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.173	0.170	0.185	0.204	0.183	0.206	0.155	0.183	0.102	0.210	0.150	0.151	0.147	0.155	0.227	0.242	0.303	0.284	0.185
2	0.272	0.254	0.243	0.257	0.254	0.252	0.265	0.230	0.232	0.192	0.243	0.205	0.219	0.228	0.223	0.269	0.302	0.319	0.319
3	0.359	0.327	0.344	0.352	0.342	0.338	0.329	0.340	0.310	0.305	0.299	0.279	0.297	0.297	0.321	0.327	0.338	0.357	0.335
4	0.394	0.404	0.397	0.451	0.472	0.457	0.437	0.427	0.431	0.415	0.420	0.364	0.357	0.417	0.372	0.425	0.466	0.423	0.400
5	0.409	0.448	0.432	0.484	0.528	0.608	0.566	0.573	0.556	0.566	0.580	0.498	0.458	0.506	0.505	0.523	0.607	0.661	0.502
6	0.466	0.452	0.473	0.498	0.508	0.647	0.697	0.725	0.677	0.713	0.740	0.661	0.555	0.578	0.596	0.712	0.798	0.807	0.968
7	0.611	0.518	0.515	0.603	0.612	0.677	0.679	1.182	0.476	0.956	0.838	0.724	0.867	0.804	0.905	0.937	1.278	0.781	0.781

WT AT AGE (MID-YR) in kg. - GEORGE'S BANK

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.198	0.200	0.211	0.185	0.197	0.182	0.139	0.138	0.091	0.213	0.215	0.208	0.236	0.234	0.212	0.220	0.223	0.211
2	0.375	0.378	0.340	0.339	0.364	0.337	0.356	0.354	0.389	0.313	0.296	0.240	0.363	0.343	0.338	0.351	0.355	0.337
3	0.464	0.500	0.492	0.545	0.527	0.513	0.462	0.495	0.493	0.487	0.440	0.378	0.497	0.540	0.523	0.557	0.543	0.419
4	0.527	0.609	0.554	0.636	0.634	0.684	0.649	0.656	0.603	0.650	0.604	0.500	0.647	0.664	0.666	0.688	0.725	0.588
5	0.603	0.680	0.618	0.741	0.782	0.793	0.728	0.813	0.707	0.748	0.736	0.642	0.733	0.823	0.680	0.855	0.883	0.699
6	0.689	0.725	0.687	0.814	0.865	0.899	0.835	1.054	0.798	1.052	0.952	0.738	0.819	0.864	0.938	1.054	1.026	0.798
7	1.082	1.001	0.675	0.857	1.025	0.939	0.955	1.224	0.833	1.057	1.005	0.971	0.733	1.015	0.790	0.939	1.254	1.207

WT AT AGE (JAN 1) in kg. - GEORGE'S BANK

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.143	0.153	0.166	0.132	0.151	0.130	0.087	0.082	0.049	0.181	0.203	0.157	0.196	0.195	0.165	0.173	0.181	0.162
2	0.325	0.274	0.261	0.267	0.259	0.258	0.255	0.222	0.232	0.169	0.251	0.227	0.275	0.285	0.281	0.273	0.279	0.274
3	0.405	0.433	0.431	0.430	0.423	0.432	0.395	0.420	0.418	0.435	0.371	0.334	0.345	0.443	0.424	0.434	0.437	0.386
4	0.464	0.532	0.526	0.559	0.588	0.600	0.577	0.551	0.546	0.566	0.542	0.469	0.495	0.574	0.600	0.600	0.635	0.565
5	0.550	0.599	0.613	0.641	0.705	0.709	0.706	0.726	0.681	0.672	0.692	0.623	0.605	0.730	0.672	0.755	0.779	0.712
6	0.645	0.661	0.683	0.709	0.801	0.838	0.814	0.876	0.805	0.862	0.844	0.737	0.725	0.796	0.879	0.847	0.937	0.839
7	1.082	1.001	0.675	0.857	1.025	0.939	0.955	1.224	0.833	1.057	1.005	0.971	0.733	1.015	0.790	0.939	1.254	1.207

Table SD4a. Stratified mean catch per tow in numbers and weight (kg) for Southern New England yellowtail flounder in NEFC offshore spring bottom trawl surveys, 1968 - 1990.

Spring	Age Group 0	1	2	3	4	5	6	7	8+	Total No/tow	Total Wt/tow
1968	0.000	1.362	25.999	26.158	15.575	0.726	0.138	0.055	0.000	70.011	18.624
1969	0.000	4.182	16.284	22.345	12.029	2.082	0.234	0.000	0.000	57.157	13.340
1970	0.000	1.218	8.745	16.364	11.587	3.333	0.898	0.193	0.079	42.417	11.721
1971	0.000	0.874	9.281	6.983	19.397	4.971	0.793	0.009	0.009	42.318	10.693
1972	0.000	0.403	17.905	12.078	3.767	7.224	1.115	0.211	0.000	42.704	10.728
1973	0.000	1.877	10.488	18.340	9.053	6.147	9.514	1.183	0.658	57.260	14.678
1974	0.000	1.070	4.288	3.355	3.650	2.376	0.856	1.390	0.278	17.262	5.040
1975	0.000	0.809	2.244	0.721	1.110	1.169	0.679	0.047	0.211	6.990	1.984
1976	0.000	0.037	4.702	0.761	0.361	0.435	0.361	0.227	0.073	6.957	2.452
1977	0.000	0.296	1.804	2.244	0.239	0.249	0.116	0.035	0.148	5.131	1.993
1978	0.000	4.275	14.113	2.924	1.032	0.270	0.052	0.068	0.199	22.931	5.146
1979	0.000	2.224	4.843	2.512	0.510	0.159	0.000	0.000	0.012	10.260	2.147
1980	0.000	0.534	6.208	4.729	3.911	0.420	0.168	0.008	0.056	16.033	5.949
1981	0.000	0.344	14.634	5.243	2.170	0.788	0.079	0.000	0.000	23.258	6.846
1982	0.000	0.321	13.548	7.193	1.794	0.583	0.179	0.019	0.000	23.637	6.001
1983	0.000	0.074	3.197	10.587	0.868	0.256	0.000	0.000	0.000	14.982	4.641
1984	0.000	0.000	0.410	1.351	2.141	0.545	0.183	0.000	0.000	4.630	1.625
1985	0.000	0.561	0.744	0.417	0.201	0.454	0.093	0.000	0.000	2.469	0.666
1986	0.000	0.037	4.083	1.492	0.308	0.073	0.036	0.000	0.000	6.028	1.605
1987	0.000	0.000	0.198	0.919	0.144	0.000	0.000	0.000	0.000	1.260	0.402
1988	0.000	0.327	0.692	0.177	0.245	0.127	0.000	0.000	0.000	1.568	0.399
1989	0.000	0.178	12.127	0.710	0.078	0.000	0.000	0.000	0.000	13.093	2.443
1990	0.000	0.107	0.433	22.346	4.464	0.036	0.000	0.000	0.000	27.386	7.828

Stratified mean catch per tow in numbers and weight (kg) for Georges Bank yellowtail flounder in NEFC offshore spring bottom trawl surveys, 1968 - 1990.

1968	0.000	0.122	2.757	2.934	0.259	0.069	0.131	0.104	0.000	6.375	2.197
1969	0.000	0.832	7.710	9.115	2.538	1.166	0.372	0.154	0.047	21.934	8.727
1970	0.000	0.076	3.676	4.943	1.985	0.467	0.099	0.156	0.000	11.403	4.150
1971	0.000	0.648	2.734	3.787	3.077	0.622	0.186	0.041	0.024	11.118	3.599
1972	0.000	0.113	5.849	5.900	2.880	0.897	0.038	0.100	0.000	15.777	5.039
1973	0.000	2.799	4.733	3.432	1.541	0.594	0.251	0.033	0.029	13.411	3.972
1974	0.000	0.458	3.223	2.669	1.821	0.501	0.271	0.123	0.013	9.078	3.676
1975	0.000	0.608	4.260	1.246	0.432	0.302	0.099	0.000	0.019	6.966	2.265
1976	0.000	1.499	6.330	1.807	0.450	0.284	0.038	0.069	0.054	10.531	3.072
1977	0.000	0.000	0.972	1.631	0.556	0.107	0.019	0.000	0.000	3.285	1.350
1978	0.000	1.356	1.157	0.735	0.318	0.038	0.000	0.011	0.000	3.616	1.002
1979	0.000	0.404	2.802	0.558	0.475	0.085	0.067	0.059	0.000	4.449	1.659
1980	0.000	0.082	6.731	8.349	0.685	0.082	0.053	0.000	0.000	15.981	6.023
1981	0.000	0.020	1.741	3.015	1.222	0.348	0.104	0.000	0.010	6.460	3.117
1982	0.000	0.044	3.633	1.089	0.986	0.442	0.063	0.000	0.025	6.282	2.298
1983	0.000	0.000	1.529	2.236	0.435	0.101	0.075	0.050	0.075	4.500	2.064
1984	0.000	0.000	0.076	0.663	0.725	0.684	0.200	0.000	0.000	2.349	1.286
1985	0.000	0.110	2.199	0.262	0.282	0.148	0.000	0.000	0.000	3.000	0.988
1986	0.000	0.027	1.806	0.291	0.056	0.137	0.055	0.000	0.000	2.373	0.847
1987	0.000	0.000	0.128	0.112	0.133	0.053	0.055	0.000	0.000	0.480	0.329
1988	0.000	0.078	0.275	0.366	0.242	0.199	0.027	0.000	0.000	1.187	0.566
1989	0.000	0.055	0.499	0.870	0.341	0.072	0.026	0.026	0.000	1.888	0.858
1990	0.000	0.000	0.077	1.303	0.462	0.164	0.014	0.053	0.000	2.072	0.822

Table SD4b. Stratified mean catch per tow in numbers and weight (kg) for Southern New England yellowtail flounder in NEFC offshore autumn bottom trawl surveys, 1963-1990.

	Age Group										
Autumn	0	1	2	3	4	5	6	7	8+	Total No/tow	Total Wt/tow
1963	0.046	16.228	16.531	12.262	4.779	0.541	0.124	0.000	0.082	50.593	16.842
1964	0.000	18.466	26.190	4.804	7.132	3.265	0.908	0.000	0.000	60.764	19.030
1965	0.258	10.845	17.533	6.370	1.754	1.776	0.127	0.000	0.074	38.735	12.675
1966	0.885	35.496	10.710	1.947	1.022	0.189	0.000	0.000	0.000	50.248	9.431
1967	0.276	18.440	25.540	11.243	1.587	0.387	0.065	0.131	0.000	57.668	14.057
1968	0.000	9.250	10.944	18.738	1.183	0.094	0.000	0.000	0.000	40.208	10.062
1969	0.000	11.870	9.741	27.755	5.206	0.093	0.041	0.041	0.000	54.747	14.401
1970	0.037	4.227	5.521	16.341	10.624	2.514	0.426	0.073	0.000	39.763	10.965
1971	0.000	6.351	10.900	6.244	15.138	2.694	0.216	0.161	0.000	41.703	9.186
1972	0.000	4.209	16.496	19.716	18.847	12.288	1.680	0.044	0.000	73.279	20.114
1973	0.000	1.415	1.303	1.823	1.344	1.017	0.866	0.174	0.000	7.940	2.264
1974	0.206	0.997	1.678	0.554	2.275	0.956	0.401	0.195	0.076	7.337	2.141
1975	0.000	1.624	0.423	0.218	0.270	0.274	0.000	0.085	0.000	2.895	0.715
1976	0.000	2.977	6.009	0.719	0.072	0.114	0.296	0.347	0.155	10.687	2.962
1977	0.044	1.696	2.194	0.798	0.051	0.044	0.109	0.075	0.000	5.010	1.501
1978	0.000	3.131	7.328	0.434	0.378	0.041	0.009	0.076	0.031	11.427	3.057
1979	0.000	1.730	4.371	2.446	0.374	0.041	0.040	0.000	0.000	9.001	2.565
1980	0.000	1.411	4.345	1.159	0.411	0.000	0.000	0.000	0.000	7.326	1.957
1981	0.000	4.536	8.625	1.354	0.322	0.077	0.059	0.000	0.000	14.973	3.789
1982	0.000	2.139	24.075	7.109	0.840	0.335	0.000	0.000	0.000	34.497	8.126
1983	0.000	3.756	14.718	8.261	0.718	0.060	0.000	0.041	0.000	27.554	6.515
1984	0.000	0.589	1.817	1.967	0.540	0.000	0.000	0.000	0.000	4.912	1.365
1985	0.000	1.198	0.526	0.189	0.144	0.000	0.000	0.000	0.000	2.057	0.438
1986	0.000	0.972	1.982	0.429	0.103	0.000	0.000	0.000	0.000	3.485	0.883
1987	0.113	1.515	0.674	0.558	0.047	0.037	0.000	0.037	0.000	2.981	0.607
1988	0.000	1.484	0.457	0.203	0.229	0.056	0.000	0.000	0.000	2.430	0.496
1989	0.000	0.000	9.416	1.647	0.077	0.000	0.000	0.000	0.000	11.140	2.359
1990	0.000	0.000	0.114	2.818	0.318	0.000	0.000	0.000	0.000	3.250	0.974

Stratified mean catch per tow in numbers and weight (kg) for George Bank yellowtail flounder in NEFC offshore autumn bottom trawl surveys, 1963-1990.

1963	0.000	12.067	6.472	9.202	1.523	0.406	0.230	0.028	0.191	30.120	9.991
1964	0.000	1.411	7.970	6.041	4.916	2.205	0.314	0.078	0.023	22.957	10.643
1965	0.014	0.933	4.573	4.480	3.164	1.478	0.133	0.233	0.031	15.038	7.113
1966	1.160	7.190	3.915	1.697	0.686	0.075	0.042	0.000	0.000	14.765	3.116
1967	0.050	7.489	7.634	2.212	0.825	0.253	0.062	0.050	0.000	18.575	5.918
1968	0.000	9.657	9.792	4.720	0.628	0.774	0.048	0.000	0.000	25.618	8.231
1969	1.054	6.644	8.509	4.799	1.362	0.453	0.122	0.149	0.000	23.092	7.249
1970	0.780	3.779	4.207	2.577	1.600	0.370	0.052	0.014	0.000	13.378	3.890
1971	0.025	2.973	5.696	4.020	1.843	0.452	0.192	0.020	0.020	15.240	4.972
1972	0.777	1.987	5.348	3.954	1.717	0.551	0.229	0.000	0.000	14.563	4.944
1973	0.100	2.044	4.506	4.184	2.413	0.997	0.341	0.141	0.025	14.751	5.070
1974	1.011	3.789	2.339	1.249	0.869	0.377	0.204	0.107	0.000	9.945	2.866
1975	0.358	3.791	2.058	0.719	0.469	0.274	0.027	0.000	0.025	7.720	1.817
1976	0.000	0.275	1.581	0.389	0.096	0.100	0.027	0.000	0.055	2.523	1.178
1977	0.000	0.901	2.098	1.601	0.600	0.110	0.054	0.035	0.016	5.414	2.556
1978	0.037	4.591	1.235	0.750	0.394	0.135	0.011	0.000	0.023	7.177	2.154
1979	0.017	1.274	1.941	0.307	0.118	0.134	0.037	0.062	0.007	3.896	1.373
1980	0.077	0.739	4.938	5.874	0.658	0.211	0.157	0.060	0.032	12.745	6.072
1981	0.038	1.538	2.265	1.583	0.485	0.117	0.081	0.013	0.000	6.118	2.367
1982	0.000	1.987	1.791	1.303	0.347	0.073	0.000	0.000	0.000	5.501	1.773
1983	0.000	0.089	1.872	1.569	0.388	0.056	0.010	0.000	0.031	4.015	1.665
1984	0.027	0.542	0.328	0.251	0.199	0.074	0.024	0.000	0.015	1.459	0.463
1985	0.010	1.418	0.553	0.178	0.062	0.073	0.000	0.000	0.000	2.293	0.732
1986	0.000	0.289	1.154	0.351	0.084	0.000	0.000	0.000	0.000	1.878	0.849
1987	0.000	0.113	0.390	0.396	0.053	0.079	0.000	0.000	0.000	1.031	0.509
1988	0.011	0.019	0.213	0.107	0.032	0.000	0.000	0.000	0.000	0.382	0.174
1989	0.027	0.292	2.344	0.910	0.081	0.078	0.000	0.000	0.000	3.732	1.149
1990	0.215	0.000	0.384	1.785	0.329	0.017	0.000	0.000	0.000	2.730	0.852

Table SD4c. Stratified mean catch per tow in numbers and weight (kg) for Southern New England yellowtail flounder in NEFC offshore scallop surveys, 1982 - 1990.

	Age Group[1]										
	0	1	2	3	4	5	6	7	8+	Total No/tow	Total[2] Wt/tow
1982	0.0000	0.5841	2.4037	0.5589	0.0543	0.0130	0.0000	0.0000	0.0000	3.614	0.719
1983	0.0000	0.8908	0.6519	0.4169	0.0380	0.0000	0.0000	0.0000	0.0000	1.998	0.392
1984	0.0000	0.2050	0.1303	0.1268	0.0334	0.0314	0.0000	0.0000	0.0000	0.527	0.162
1985	0.0000	0.6466	0.1801	0.0267	0.0229	0.0099	0.0000	0.0000	0.0000	0.886	0.127
1986	0.0000	0.2816	0.3952	0.0505	0.0281	0.0000	0.0000	0.0000	0.0000	0.755	0.0
1987	0.0000	0.6012	0.0858	0.0748	0.0109	0.0057	0.0000	0.0041	0.0000	0.783	0.0
1988	0.0000	1.3425	0.0470	0.0537	0.0076	0.0008	0.0000	0.0000	0.0000	1.452	0.0
1989	0.0000	0.1687	3.8778	0.5763	0.0385	0.0141	0.0000	0.0000	0.0000	4.675	0.0
1990	0.0052	0.0258	0.1796	0.5919	0.0377	0.0000	0.0000	0.0000	0.0000	0.840	0.0

Stratified mean catch per tow in numbers and weight (kg) for Georges Bank yellowtail flounder in NEFC offshore scallop surveys, 1982 - 1990.

	Age Group[1]										
	0	1	2	3	4	5	6	7	8+	Total No/tow	Total[2] Wt/tow
1982	0.0000	0.4855	0.4991	0.1947	0.0750	0.0158	0.0000	0.0000	0.0000	0.127	0.345
1983	0.0000	0.1831	0.5316	0.4038	0.0823	0.0346	0.0000	0.0000	0.0177	1.253	0.489
1984	0.0000	0.2945	0.1177	0.0501	0.0822	0.0194	0.0006	0.0000	0.0000	0.565	0.169
1985	0.0000	0.4559	0.0601	0.0030	0.0089	0.0000	0.0000	0.0000	0.0000	0.528	0.093
1986	0.0000	0.1451	0.1005	0.0056	0.0037	0.0000	0.0000	0.0000	0.0000	0.255	0.0
1987	0.0000	0.0230	0.1469	0.0697	0.0115	0.0060	0.0000	0.0000	0.0000	0.257	0.0
1988	0.0000	0.0995	0.0460	0.0352	0.0387	0.0157	0.0000	0.0000	0.0000	0.235	0.0
1989	0.0000	0.0831	0.4775	0.1997	0.0573	0.0000	0.0000	0.0000	0.0000	0.818	0.0
1990	0.0000	0.0125	0.1125	0.3198	0.0705	0.0000	0.0000	0.0000	0.0000	0.515	0.0

1) Age length keys from the 1982-1990 autumn NEFC bottom trawl surveys were applied to 1982-1990 length samples from NEFC scallop surveys.

2) Weight recorded only for 1982-1985.

Table SD5. Assessment Results for Southern New England Yellowtail Flounder.

a) Fishing Mortality Rates at age.

Age	Year 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0049	0.1085	0.4132	0.0185	0.1352	0.2026	0.0075	0.0264	0.0003	0.0035	0.2132	0.0456	0.0934	0.0686	0.1540
2	0.4571	2.4300	0.9566	0.6285	0.7097	0.5663	0.9320	0.6013	0.2521	0.4680	0.6341	1.0743	0.6012	1.4739	1.3028
3	0.6189	1.0791	1.1046	0.6385	1.0304	0.5032	0.8798	0.9683	1.1346	1.2416	1.6153	2.0463	0.9536	1.2601	1.5414
4	0.7155	1.0293	0.6831	0.5185	0.6353	0.8391	0.8011	1.3650	1.4705	1.1010	1.3409	1.8906	1.3239	1.3123	1.9630
5	0.6885	1.1501	0.7809	0.5271	1.1806	0.6069	1.1037	1.1582	2.0440	1.1289	0.7509	1.4202	1.5996	1.7347	1.7053
6	0.6663	1.1086	0.8674	0.5971	1.0122	0.6099	0.9013	1.1219	1.3043	1.2742	1.6797	2.1900	1.2190	1.3595	1.7614
7+	0.6663	1.1086	0.8674	0.5971	1.0122	0.6099	0.9013	1.1219	1.3043	1.2742	1.6797	2.1900	1.2190	1.3595	1.7614

	1988	1989	1990
1	0.0562	0.0000	0.0953
2	0.3939	0.3440	0.2988
3	0.7357	0.4862	1.6062
4	2.0590	1.3026	1.6062
5	2.6044	1.9363	1.6062
6	1.1001	0.5629	1.6062
7+	1.1001	0.5629	1.6062

b) Stock Numbers (Jan 1) in millions

Age	Year 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	42.145	9.228	28.861	12.907	47.568	52.417	30.090	41.945	126.927	53.167	14.541	12.668	21.036	6.349
2	15.231	34.335	6.779	15.631	10.374	34.021	35.045	24.451	33.449	103.885	43.376	9.619	9.909	15.686
3	19.879	7.895	2.475	2.132	6.826	4.177	15.811	11.298	10.972	21.282	53.267	18.837	2.690	4.447
4	10.104	8.765	2.197	0.671	0.922	1.994	2.068	5.370	3.512	2.889	5.034	8.671	1.993	0.849
5	3.811	4.045	2.564	0.909	0.327	0.400	0.706	0.760	1.123	0.661	0.786	1.078	1.072	0.434
6	3.443	1.567	1.048	0.961	0.439	0.082	0.178	0.192	0.195	0.119	0.175	0.304	0.213	0.177
7+	0.703	1.968	0.885	0.861	0.484	0.170	0.043	0.049	0.021	0.011	0.056	0.024	0.047	0.032
1+	95.316	67.803	44.809	34.072	66.939	93.261	83.941	84.065	176.200	182.013	117.235	51.201	36.960	27.974

	1987	1988	1989	1990	1991
1	9.583	119.319	4.053	1.581	0.000
2	4.854	6.726	92.353	3.318	1.177
3	2.941	1.080	3.714	53.605	2.015
4	1.033	0.516	0.424	1.870	8.806
5	0.187	0.119	0.054	0.094	0.307
6	0.063	0.028	0.007	0.006	0.015
7+	0.011	0.009	0.000	0.000	0.001
1+	18.671	127.797	100.605	60.475	12.322

C) Mean Biomass at age (1000's MT).

Age	Year 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	8.002	1.612	4.703	2.643	8.690	10.097	5.136	7.733	16.103	10.872	2.084	2.044	3.336	1.036	1.993
2	3.327	3.731	1.165	3.220	1.935	7.034	6.314	4.727	7.050	19.930	7.708	1.300	1.800	2.170	0.673
3	5.171	1.599	0.532	0.616	1.512	1.206	3.539	2.559	2.078	3.990	8.377	2.235	0.591	0.783	0.503
4	2.780	2.164	0.641	0.253	0.326	0.674	0.622	1.354	0.826	0.811	1.281	1.410	0.438	0.206	0.174
5	1.086	1.059	0.712	0.344	0.094	0.195	0.233	0.287	0.277	0.242	0.341	0.265	0.269	0.115	0.045
6	1.165	0.416	0.302	0.376	0.123	0.045	0.074	0.095	0.067	0.051	0.065	0.075	0.071	0.055	0.016
7	0.288	0.568	0.280	0.358	0.172	0.079	0.018	0.032	0.005	0.005	0.021	0.007	0.022	0.013	0.004
1+	21.819	11.149	8.336	7.811	12.850	19.329	15.935	16.786	26.406	35.901	19.878	7.336	6.526	4.378	3.409

	1988	1989	1990
1	28.420	1.142	0.412
2	1.486	24.005	0.854
3	0.279	1.045	9.376
4	0.102	0.120	0.399
5	0.026	0.016	0.035
6	0.015	0.005	0.003
7	0.005	0.000	0.000
1+	30.334	26.334	11.078

Table SD6. Georges Bank Yellowtail Flounder Assessment Results from VPA.

a) Fishing Mortality rates at age.

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0116	0.1269	0.0514	0.0287	0.0262	0.2372	0.0104	0.0144	0.0007	0.0514	0.3921	0.0469	0.1663	0.0539	0.0053
2	0.4353	0.7371	1.1731	0.9309	0.6276	0.2496	0.4072	0.3428	0.1369	0.4101	0.7764	0.7241	0.7964	0.8487	0.6074
3	0.6986	0.9050	1.3284	0.9457	1.4220	0.9893	0.7404	0.7787	0.7370	0.8393	1.2341	1.5642	0.8056	0.5740	1.3797
4	0.9711	1.1222	1.4160	1.0569	1.0523	1.0436	1.0376	0.8208	1.3991	1.3141	0.7485	2.1098	1.2233	1.0346	1.3356
5	1.2217	1.4506	1.2480	0.9137	1.1135	0.9368	1.3701	0.8511	2.0488	1.8554	1.0096	2.7215	1.4550	1.2893	1.8015
6	0.8479	1.0926	1.4041	0.9914	1.4078	1.0308	0.8571	0.8039	0.9831	1.0163	1.1759	2.0802	1.0556	0.6968	1.4557
7	0.8479	1.0926	1.4041	0.9914	1.4078	1.0308	0.8571	0.8039	0.9831	1.0163	1.1759	2.0802	1.0556	0.6968	1.4557

Age	1988	1989	1990
1	0.0000	0.1969	0.0000
2	0.4097	0.1362	0.9126
3	1.0880	0.2182	1.2518
4	1.7739	0.7617	0.3907
5	1.3597	1.0592	0.8212
6	1.3132	0.2877	0.8212
7	1.3132	0.2877	0.8212

b) Stock Numbers at age (millions; Jan 1).

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	33.182	50.313	57.124	20.091	14.102	50.543	26.766	23.844	56.211	20.350	7.420	8.591	16.594	5.691
2	28.209	26.853	36.285	44.425	15.983	11.247	32.641	21.687	19.242	45.991	15.827	4.105	6.712	11.504
3	29.776	14.944	10.520	9.191	14.338	6.986	7.175	17.786	12.603	13.739	24.986	5.962	1.629	2.478
4	16.502	12.123	4.950	2.282	2.923	2.832	2.127	2.802	6.684	4.938	4.860	5.955	1.021	0.596
5	5.865	5.116	3.231	0.983	0.649	0.835	0.817	0.617	1.009	1.351	1.086	1.882	0.591	0.246
6	2.433	1.415	0.982	0.759	0.323	0.175	0.268	0.170	0.216	0.107	0.173	0.324	0.101	0.113
7	0.685	1.019	0.684	0.752	0.364	0.122	0.246	0.027	0.006	0.037	0.028	0.078	0.008	0.050
1+	116.653	111.784	113.775	78.484	48.682	72.740	70.039	66.932	95.972	86.512	54.381	26.896	26.656	20.678

Age	1987	1988	1989	1990	1991
1	8.694	25.210	7.118	0.830	0.000
2	4.415	7.081	20.640	4.786	0.679
3	4.031	1.969	3.849	14.747	1.573
4	1.143	0.831	0.543	2.533	3.453
5	0.173	0.246	0.115	0.208	1.403
6	0.055	0.023	0.052	0.033	0.075
7	0.101	0.033	0.033	0.005	0.014
1+	18.612	35.393	32.351	23.142	7.197

c) Mean Biomass at age (1000's MT).

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	5.921	8.583	10.657	3.322	2.486	7.451	3.355	2.962	4.635	3.833	1.204	1.583	3.279	1.176	1.666
2	7.830	6.588	6.709	9.019	3.957	3.053	8.710	5.925	6.355	10.776	2.991	0.643	1.542	2.444	1.024
3	9.115	4.523	2.652	2.982	3.738	2.096	2.149	5.615	4.033	4.161	5.839	1.058	0.511	0.932	1.060
4	5.124	4.095	1.360	0.826	1.057	1.108	0.792	1.152	2.011	1.653	1.896	1.161	0.352	0.227	0.389
5	1.887	1.703	1.055	0.440	0.283	0.396	0.300	0.310	0.284	0.429	0.464	0.391	0.212	0.105	0.051
6	1.039	0.576	0.336	0.361	0.139	0.090	0.138	0.113	0.101	0.065	0.089	0.094	0.047	0.064	0.025
7	0.459	0.572	0.230	0.376	0.185	0.066	0.145	0.021	0.003	0.023	0.016	0.030	0.004	0.033	0.039
1+	31.376	26.641	22.998	17.326	11.845	14.261	15.588	16.097	17.421	20.939	12.499	4.961	5.947	4.982	4.254

Age	1988	1989	1990
1	5.027	1.310	0.159
2	1.861	6.223	0.973
3	0.617	1.708	3.260
4	0.249	0.253	1.125
5	0.107	0.058	0.091
6	0.013	0.042	0.016
7	0.016	0.033	0.004
1+	7.889	9.627	5.627

Table SD7. Input Parameters for Yield and Spawning Stock Biomass Per Recruit Calculations for Yellowtail Flounder.

a) Southern New England

Age	F Mort Pattern	Proportion Mature	Average Weights w/Discards	Average Weights w/out Discards
1	0.06	0.13	0.084	0.263
2	0.47	0.74	0.257	0.302
3	1.0	0.98	0.373	0.372
4	1.0	1.0	0.501	0.478
5	1.0	1.0	0.664	0.668
6	1.0	1.0	0.798	0.798
7+	1.0	1.0	0.941	0.941

Note: Average weights without discards are assumed equal to commercial weight at age for the first 3-5 ages only.

b) Georges Bank

Age	F Mort Pattern	Proportion Mature	Average Weights w/Discards	Average Weights w/out Discards
1	0.13	0.0	0.112	0.220
2	0.44	0.88	0.362	0.345
3	1.0	1.0	0.577	0.516
4	1.0	1.0	0.666	0.666
5	1.0	1.0	0.730	0.730
6	1.0	1.0	0.860	0.860
7+	1.0	1.0	1.041	1.041

Table SD8a. Projections for Southern New England Yellowtail Flounder.

Recruitment	1991 F	1991 Rein.	1991 Land.	1991 Disc.	1991 SSB	1992 F	1992 Rein.	1992 Land.	1992 Disc.	1992 SSB	1993 SSB
	$F_{sq}=1.606$	4203	3936	267	2757	$F_{sq}=1.606$	1814	1439	375	1487	1390
Low	"	4203	3936	267	2757	$F_{0.1}=0.218$	385	306	79	2226	3490
((8,200)	"	4203	3936	267	2757	$F_{20\%}=0.493$	789	626	163	2050	2820
	"	4303	3945	358	2895	$F_{sq}=1.606$	3243	2218	1025	2983	3591
Medium	"	4303	3945	358	2895	$F_{0.1}=0.218$	641	426	215	4151	7983
(22,500)	"	4303	3945	358	2895	$F_{20\%}=0.493$	1335	890	445	3881	6658
	"	4572	3972	600	3266	$F_{sq}=1.606$	7080	4310	2770	7001	9502
High	"	4572	3972	600	3266	$F_{0.1}=0.218$	1328	747	581	9322	20049
(60,900)	"	4572	3972	600	3266	$F_{20\%}=0.493$	2801	1598	1203	8798	16966

Table SD8b. Projections for Georges Bank Yellowtail Flounder.

Recruitment	1991 F	1991 Rein.	1991 Land.	1991 Disc.	1991 SSB	1992 F	1992 Rein.	1992 Land.	1992 Disc.	1992 SSB	1993 SSB
Low (10,600)	F_{Sq}=0.821	2395	2256	139	2988	F_{Sq}=0.821	1907	1706	201	3259	4186
	"	2395	2256	139	2988	$F_{0.1}$=0.247	692	622	70	3826	6319
	"	2395	2256	139	2988	$F_{20\%}$=0.580	1453	1303	150	3484	4946
Medium ((23,800)	"	2531	2292	239	2988	F_{Sq}=0.821	3015	2579	436	5707	8725
	"	2531	2292	239	2988	$F_{0.1}$=0.247	1063	913	150	6547	12667
	"	2531	2292	239	2988	$F_{20\%}$=0.580	2272	1946	326	6043	10155
High (53,500)	"	2836	2375	461	2988	F_{Sq}=0.821	5507	4543	964	11218	18936
	"	2836	2375	461	2988	$F_{0.1}$=0.247	1898	1566	332	12668	26951
	"	2836	2375	461	2988	$F_{20\%}$=0.580	4113	3393	720	11803	21877

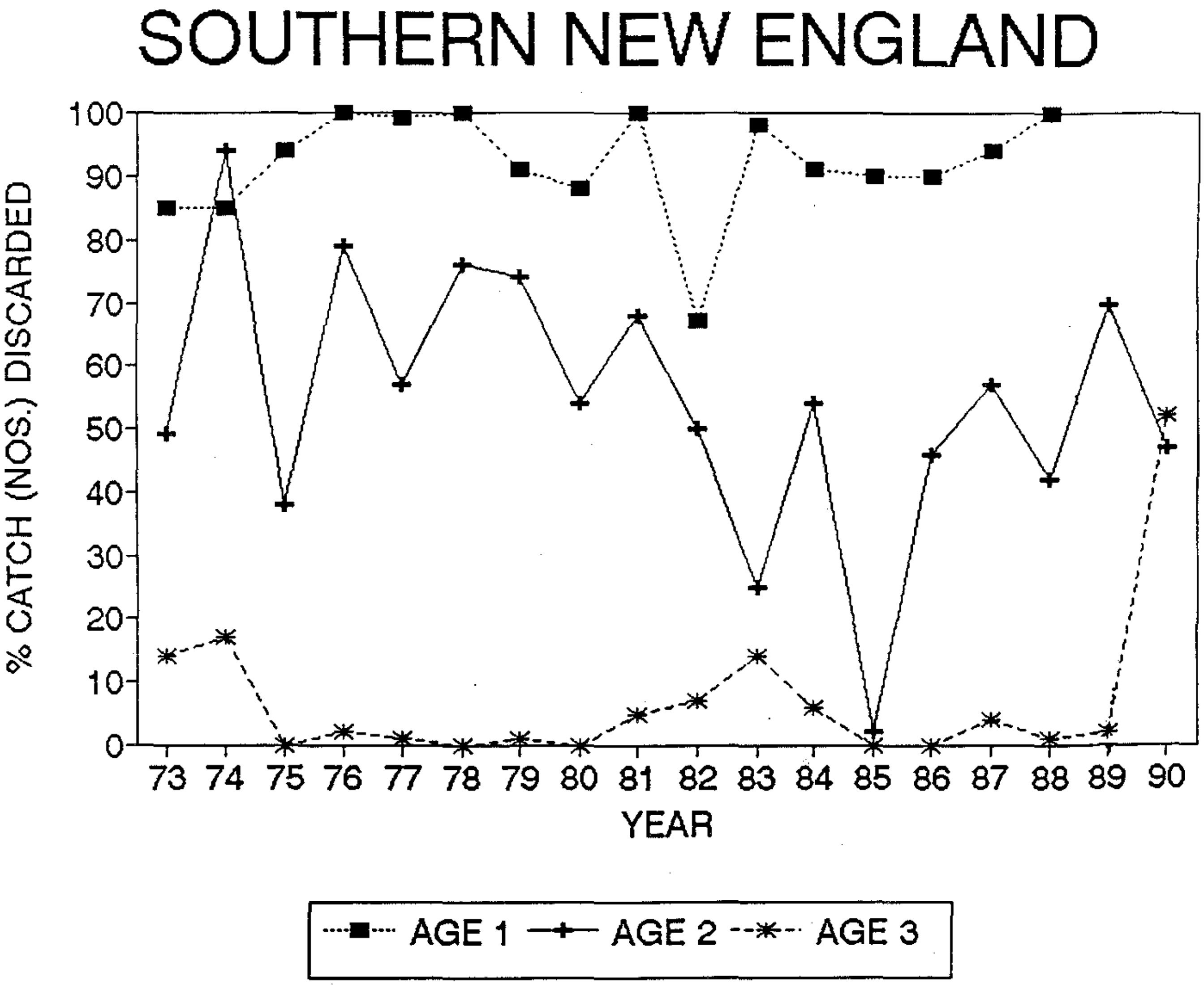
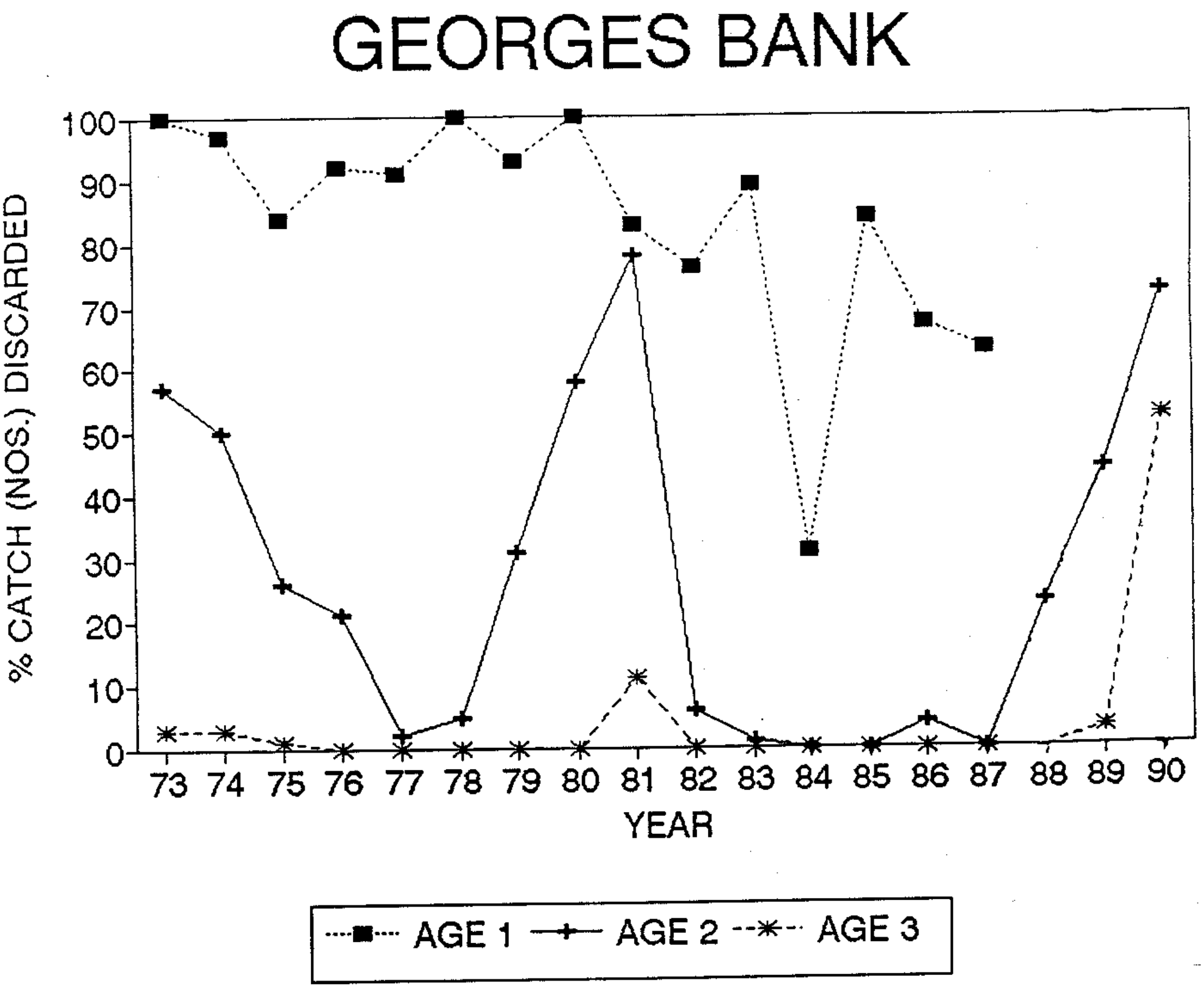


Figure SD1a. Annual proportion of the catch in numbers discarded by age for Southern New England yellowtail flounder



FigureSD1b. Annual proportion of the catch in numbers discarded by age for Georges Bank yellowtail flounder.

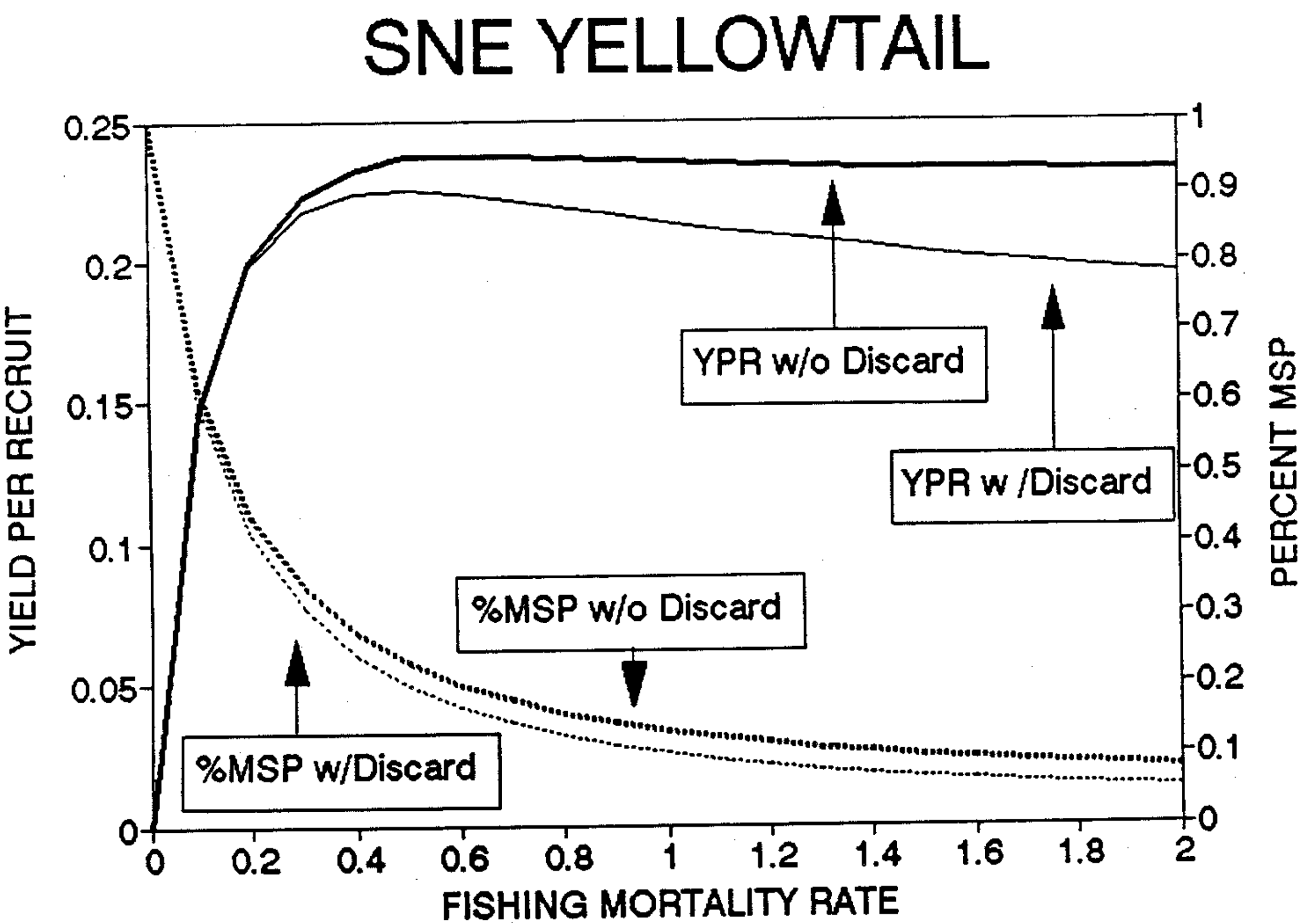


Figure SD2a. Yield and spawning biomass per recruit for Southern New England yellowtail flounder, with and without discards.

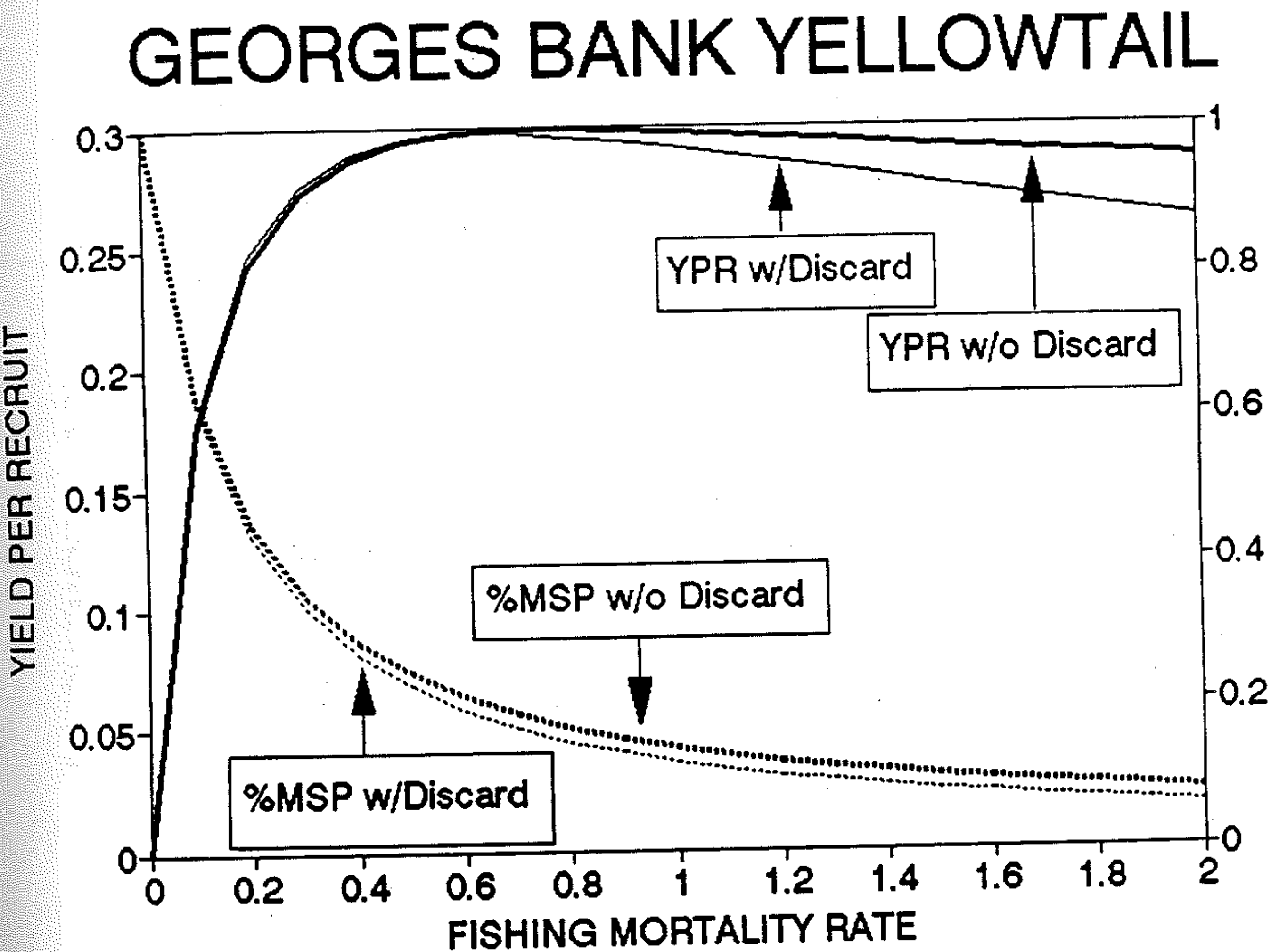


Figure SD2b. Yield and spawning biomass per recruit for Georges Bank yellowtail flounder, with and without discards.

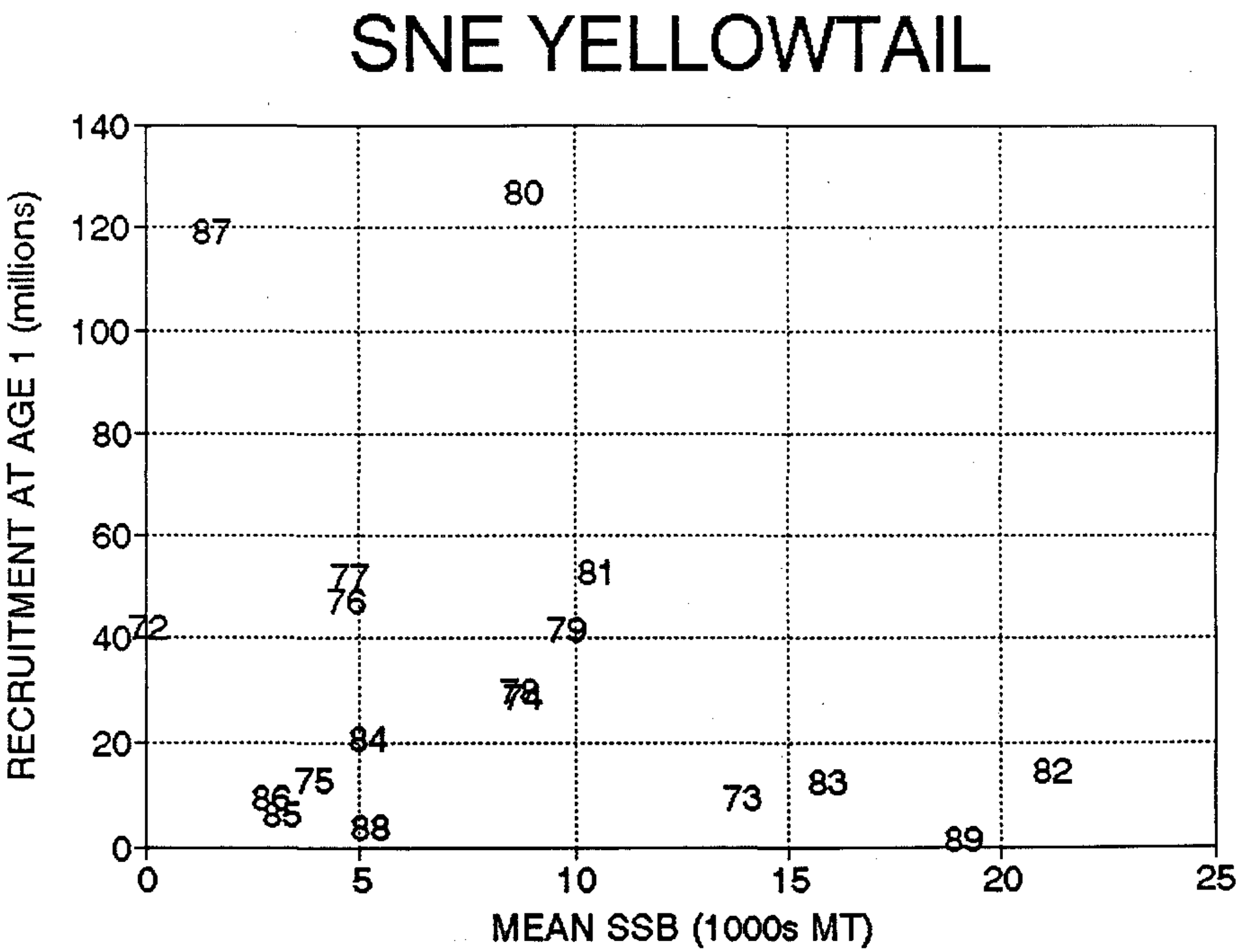


Figure SD3a. Stock and recruitment data for Southern New England yellowtail flounder. The datapoint labels indicate the year class of each cohort.

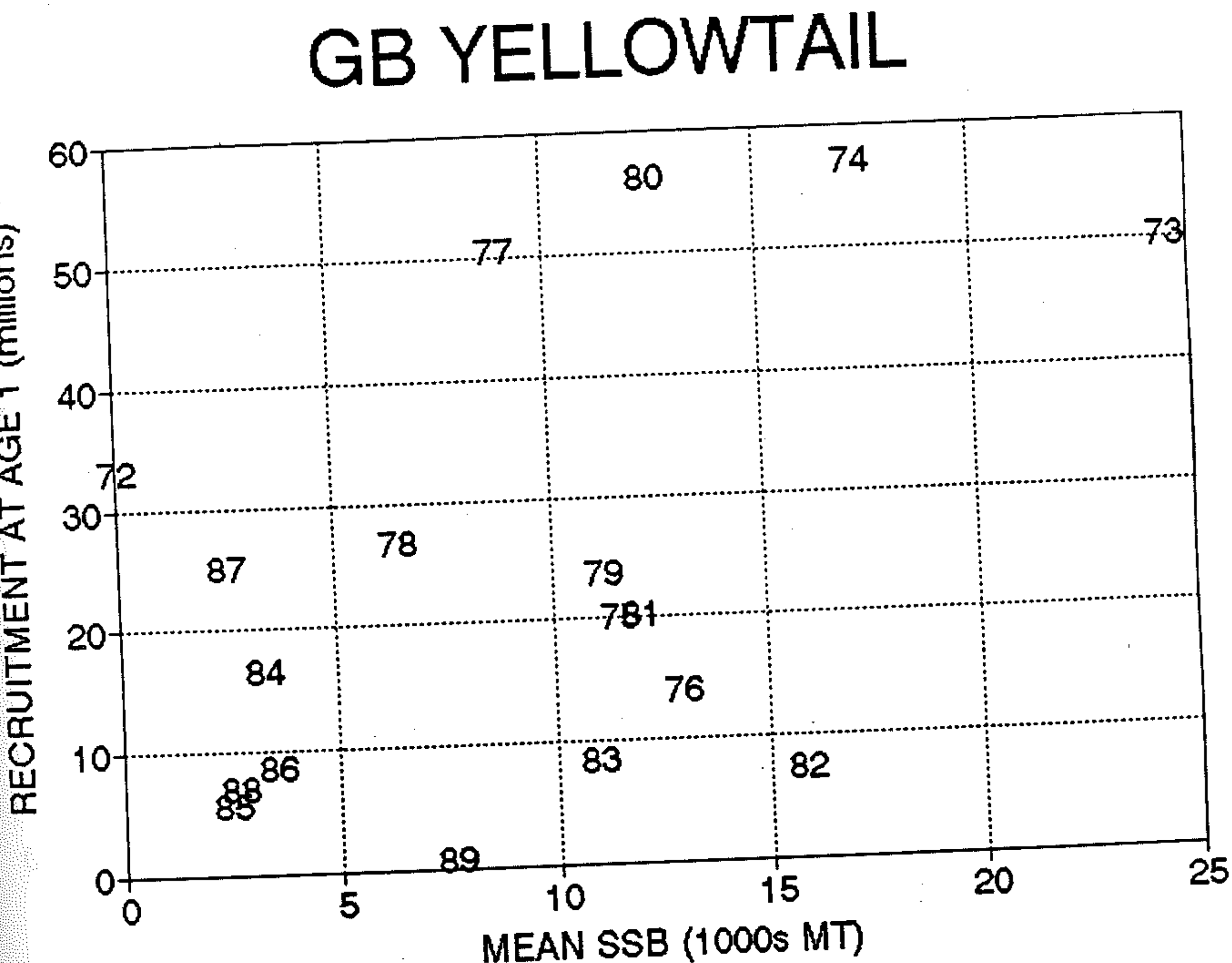


Figure SD3b. Stock and recruitment data for Georges Bank yellowtail flounder
The datapoint labels indicate the year class of each cohort.

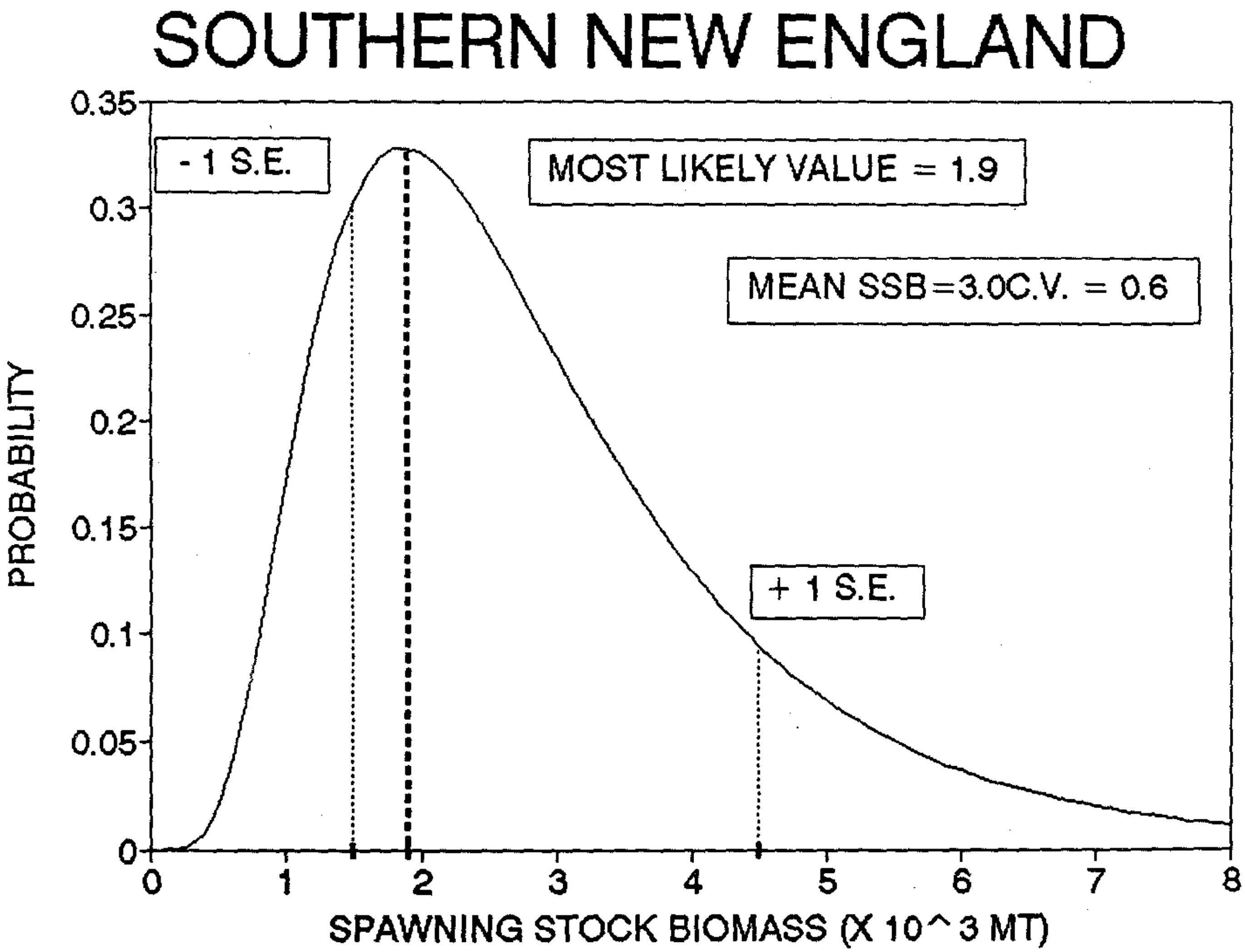


Figure 8D4a. Uncertainty graph for 1991 Southern New England yellowtail flounder SSB.

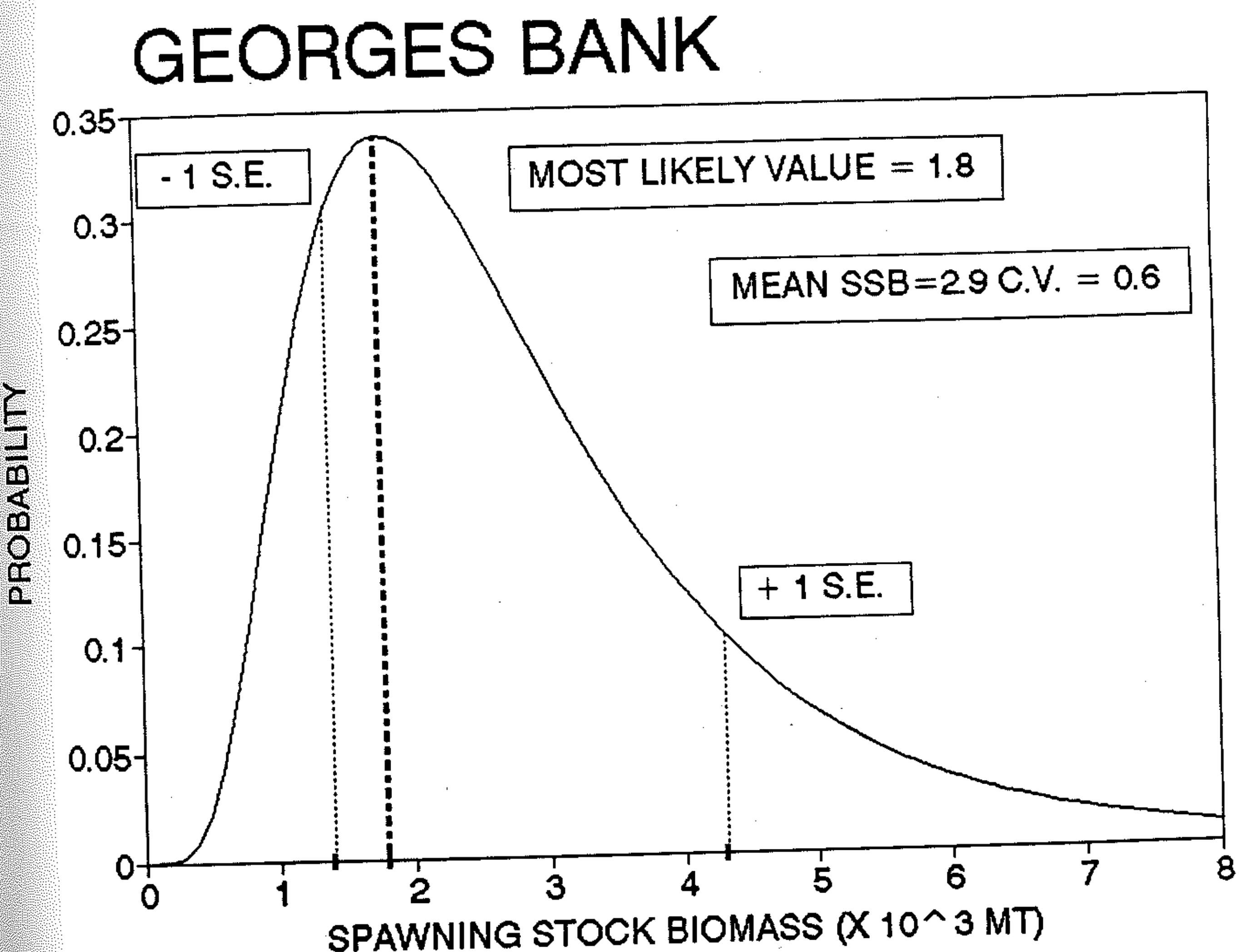


Figure SD4b. Uncertainty graph for 1991 Georges Bank yellowtail flounder SSB.

SHORT FIN SQUID

An updated, index level assessment was presented in SAW/12/SARC/6. The general conclusion of the SARC was that the Illex illecebrosus population is at a relatively high level of abundance compared to historical levels. Current levels of fishing on Illex have increased in recent years but the SARC found no evidence of over-exploitation of this resource.

Background

The short fin squid population is assumed to constitute a unit stock throughout its range of commercial exploitation from Cape Hatteras to Newfoundland. Illex migrate offshore in late autumn and return to nearshore waters in the summer to feed. Illex appear to exhibit a cross-over life cycle where squid hatched in the winter spawn in the summer of the following year, and squid hatched in the summer spawn in the winter of the following year (Mesnil 1977), although the location of spawning grounds have not been determined (Lange 1980). This cross-over pattern could lead to unstable population dynamics under high exploitation of the resource.

The landings history of the Illex fishery is given in Table SE1. Domestic landings were a record in 1990, increasing by 66% over 1989 landings and 55% above the average domestic landings from 1982-1990. Landings increased in all areas except area 53 with the majority of landings (81%) occurring south of Delaware Bay (SA's 621-632). In comparison to 1989 when virtually all (99%) of the landings taken from June to September, the 1990 season extended into November with roughly 16% of the total landings taken in October and November.

Data Sources

Landings data for 1989 and 1990 were obtained from Joint Venture, general canvass, and NMFS weighout databases to update the data for 1963-1988 presented in the Report of the 10th SAW (NEFC 1990). Effort data used in catch per unit effort (CPUE) calculations for 1982-1990 were obtained from NMFS weighout databases. Illex CPUE statistics for total and directed effort, where directed effort is defined as total landings (MT) per total days fished in trips by vessels over 5 GRT that land over 95% Illex were developed (Table SE2).

Discards in the directed Illex fishery are believed minimal. Length information from the commercial fishery exists but was not used in this assessment update. No age composition nor mean weight at age data were evaluated.

The NEFC autumn bottom trawl survey data for 1967-1990 were analyzed (Table SE3). Indices of relative abundance for Illex are stratified mean number per tow of all sizes and pre-recruits (< 10 cm).

Age at 50% maturity is 18 months (NEFC 1989) with a corresponding size of about 20 cm (7.9 in.). Maximum age is about 24 months.

Methodology

The assessment used the methodology and data sources of recent Illex assessments (NEFC 1990), which compared survey indices and landings and commercial catch-per-unit-effort to the historical pattern to indicate the performance of the stock in response to exploitation.

The previous definition of directed CPUE for Loligo was restricted to trips in areas 622 through 636 (NEFC 1990). In 1990, there were significant Loligo landings in areas 525, 526, 615, 616, and 621 so the directed CPUE index for Illex was redefined to be the total landings per day fished for trips landing more than 95% Illex in any statistical area. As with other stocks, the SARC recommended that a statistical approach to the analysis of CPUE data be taken in future.

Assessment Results

The 1990 all sizes research survey index is 74% above the 1967-1990 mean, while the pre-recruit index is equal to the 1967-1990 mean (Table SE3). In comparison to 1989, the 1990 all sizes increased by 10%, while the pre-recruit index dropped by 37%. Over the 24 year span of autumn survey data, the Illex all sizes index has alternated between periods of relatively high (1975 to 1981 and 1987 to present) or relatively low (1967 to 1974 and 1982 to 1986) levels. The coefficients of variation on the total number per tow are: 1990=10%, 1989=27%, and 1988=17%. The all sizes index is positively correlated with directed (r=0.70) and total (r=0.67) CPUE indices during 1982-1990. This suggests that the all sizes index provides a rough measure of population abundance and subsequent availability to the domestic commercial fishery.

In comparison to 1989, directed effort increased by 187% in 1990, while directed CPUE fell by 45%. The decrease in CPUE in 1990 is likely the result of the substantial increase in directed and total effort (Table SE2) reducing available concentrations of Illex and the extension of the fishing season into November. The increase in directed and total effort for Illex is likely the result of enhanced export opportunities for U. S. Illex in the world squid market (MAFMC 1990A).

The three year moving average of the pre-recruit index provides an empirical reference point for Illex production, and this moving average was 1.256 for 1990. This is well above the lowest quartile of the data series on pre-recruit indices. Given the high indices in 1989 and 1990, this moving average will not approach the lowest quartile of the data in 1991 or 1992 even if subsequent recruitment is very poor.

Other biological reference points (i.e., $F_{0.1}$ and F_{max}) have not been calculated for this species (NEFC 1989).

SARC Analyses

The SARC had no major difficulties with the analyses presented. Discussion mostly focused on speculation of Illex availability both to the survey and the fishery since the US EEZ is likely the edge of the distribution.

Major Sources of Uncertainty

- Availability to the commercial fishery and to the survey may vary as much or more than actual stock abundance. It is likely that only the edge of the stock's distribution is available to the fleet and this results in substantial year to year variation in catch rates, largely as a result of environmental conditions. Similarly, the research survey coverage does not cover the entire stock and this contributes to the high variability of the survey indices and assessment uncertainty.

- The cross-over life cycle makes the definition of cohorts problematic and the response of the stock to exploitation is uncertain because of this life history pattern.

Recommendations

- Develop a statistically based analysis of the directed fishery.

- Calculate and report the coefficients of variation on the research survey indices prior to 1988 to examine variability.

- Develop a survey specifically designed to estimate the relative abundance of pelagic stocks.

- Analyze the spatial distribution pattern for this species and its inter-annual variability with respect to environmental conditions to identify the factors contributing to resource availability, including Canadian survey data for the Scotian Shelf and Newfoundland.

- Develop alternative biological reference points for squid taking into account its life history pattern.

- Apply MULTIFAN to survey and commercial length frequency data to estimate growth and mortality rates.

Table SE1. Annual short-finned squid landings (in metric tons) from the Northwest Atlantic (Cape Hatteras to Gulf of Maine) by the domestic and foreign fleets, 1963-90.

Year	Domestic	Foreign	Total
1963	810	0	810
1964	358	2	360
1965	444	78	522
1966	452	118	570
1967	707	285	992
1968	678	2,593	3,271
1969	562	975	1,537
1970	408	2,418	2,826
1971	455	159	614
1972	472	17,169	17,641
1973	530	18,625	19,155
1974	148	20,480	20,628
1975	107	17,819	17,926
1976	229	24,707	24,936
1977	1,024	23,771	24,795
1978	385	17,310	17,695
1979	1,780	15,742	17,522
1980	349	17,529	17,878
1981	631	14,723	15,354
1982	5,902	12,350	18,252
1983	9,944	1,776	11,720
1984	9,547	676	10,223
1985	4,997	1,053	6,050
1986	5,176	250	5,422
1987	10,260	0	10,260
1988	1,966	1	1,967
1989	6,802	0	6,802
1990	11,316	0	11,316

Table SE2. Directed and total catch per unit effort (MT/day fished) for Illex during 1982-1990 in the domestic fishery.

	Directed		Total	
Year	CPUE	Days Fished	CPUE	Days Fished
1982	33.0	98.0	6.0	589.3
1983	21.9	58.8	5.8	245.0
1984	50.6	63.7	14.3	229.9
1985	27.8	49.6	13.0	187.5
1986	44.6	85.3	15.2	289.1
1987	55.6	115.0	24.6	282.6
1988	52.9	26.1	12.3	158.6
1989	65.0	99.0	39.9	170.5
1990	35.5	283.8	25.6	441.8
Mean	43.0	97.7	17.4	288.3

Table SE3. Short-finned squid abundance and pre-recruit indices from NEFC autumn surveys, 1967-1990.

Year	Mean Number Per Tow[1] Total	Pre-Recruit	Pre-Recruit Ratio[2]
1967	2.1	0.1	0.03
1968	2.3	0.2	0.07
1969	0.8	0.1	0.17
1970	3.4	1.5	0.43
1971	1.9	0.3	0.16
1972	3.5	1.1	0.30
1973	1.3	0.1	0.05
1974	3.0	1.8	0.60
1975	12.4	6.2	0.50
1976	28.7	0.6	0.02
1977	15.8	1.1	0.07
1978	29.4	5.1	0.17
1979	32.1	2.6	0.08
1980	17.1	0.7	0.04
1981	61.9	0.4	0.01
1982	4.7	1.3	0.24
1983	2.8	0.2	0.08
1984	6.4	0.4	0.07
1985	2.0	0.3	0.17
1986	3.2	0.5	0.16
1987	30.0	1.3	0.04
1988	24.0	0.7	0.03
1989	22.2	1.9	0.09
1990	24.5	1.2	0.05
Mean	14.1	1.2	0.15

[1] Stratified mean number per tow of all size individuals (total) and of pre-recruits (≤10cm), Mid-Atlantic to Georges Bank.

[2] Ratio of pre-recruits to total mean numbers per tow.

LONG FIN SQUID

An assessment of this (Loligo pealei) resource was presented to the SARC in SAW/12/SARC/7. The assessment considers the historical pattern of abundance indices with respect to the performance of the fishery. In general, these indices show that abundance remains relatively high in comparison to periods of heavy exploitation, primarily by distant-water fleets. Several new approaches to examining the fishery were taken with promising preliminary results for more detailed assessment and forecasting of future stock availability.

Background

Loligo pealei range from Nova Scotia to the northern coast of South America. They are assumed to constitute a unit stock throughout their range of commercial exploitation in the Northwest Atlantic from Nova Scotia to Cape Hatteras although this assumption needs further evaluation since the squid population may actually be comprised of separate sub-stocks or breeding units.

North of Cape Hatteras, Loligo migrate offshore during late autumn to overwinter in deeper waters. They migrate inshore during the spring or summer with larger individuals moving inshore before smaller ones. In general, differences in migratory timing can be attributed to the cross-over life cycle involving a return of spring-spawned hatchlings to spawn in the summer of the following year with hatchlings spawned in late-summer returning to spawn in the spring two years later (Mesnil 1977). This cross-over life cycle and the production of early (spring) and late (summer) cohorts complicates stock (or sub-stock) assessments and management.

The domestic fishery in the Northwest Atlantic began in the late 1800s with squid being used primarily for bait. From 1928 to 1967, annual landings from Maine to North Carolina (including Illex landings) averaged 1,000 to 2,000 MT (Lange 1980). A directed foreign fishery for Loligo developed in 1967, and foreign fishing fleets exploited Loligo throughout the 1970s and early 1980s.

Table SF1 show annual Loligo landings in the Northwest Atlantic from 1963-1990. Annual landings averaged about 19,900 MT from 1967-1986. Since 1986, foreign allocations have been curtailed, and domestic landings have averaged about 17,300 MT. Presently, the fishery is entirely a domestic fishery. Detailed landings breakdowns by month, area and market category are given in SAW/12/SARC/7.

Data Sources

The commercial fishery landings data for 1989 and 1990 were obtained from Joint Venture, general canvass, and NMFS weighout databases to update the information given in the last assessment report (NEFC 1990). No information is available on the discarding of squid and the amount of discarding was not discussed by the SARC.

Effort data used in catch per unit effort (CPUE) calculations for 1982-1990 were obtained from the NMFS interview database. The previous definition of directed catch per unit effort for Loligo was restricted to trips in areas 537 through 636 (NEFC 1990, see Table 23). In 1989 there were significant Loligo landings in area 526; the CPUE index for Loligo was redefined to be the total landings per day fished for trips landing more than 75% Loligo in any statistical area. Table SF4 shows catch per unit effort (CPUE) statistics for the directed fishery from 1982-1990.

Indices of relative abundance are the stratified mean number per tow of all sizes, pre-recruits and recruits obtained in the NEFC autumn bottom trawl survey for the period 1965-1990. Pre-recruits were considered to be all squid less than 9 cm. Recruits were all squid greater than 8 cm. Individual cohorts (i.e., spring and late summer) were not separated. Pre-recruits for each cohort in a given survey were not distinguished. Table SF3 shows these indices for 1967-1990.

Methodology

The primary method of assessment for this resource is a comparison of recent survey indices of abundance with respect to historical patterns and fishery performance. In addition, because of the short life span of squid and inter-annual variation in the availability of the resource, some effort to develop forecasting models of Loligo relative abundance and catch has been made. The following methods were used:

1) Regression analyses of the fall recruit index as a function of stratified mean bottom temperature to determine if the recruit index was dependent on temperature.

2) Time series methods applied to the series of recruit indices for 1967-1990 to examine the potential for developing a predictive model for the recruit index. Standard model identification procedures (Box and Jenkins 1976) were applied. Model parameters were estimated using the recruit series from 1967-1988 to provide an in-sample forecast of the 1990 recruit index for comparison with the observed value. Model parameters were then re-estimated using the recruit series from 1967-1990 to provide an out-of-sample forecast for 1991.

3) The number of zero tows (where no squid were caught) on the autumn trawl survey was used in previous assessments as a predictor of availability. The SARC calculated this value for 1990 for comparison to the other methods.

The SARC was also presented with a preliminary analysis of the Loligo fishery in area 538 using a Leslie-DeLury model (Rosenberg et al 1990) as suggested in SAW 11. The details of this analysis are discussed in the SAW Plenary session on squid. The intent was to estimate the population abundance and mortality rate for squid using the decline in commercial CPUE through the season in this area. While the results are encouraging, a substantial amount of additional work will be needed before this approach can be used for advice.

Assessment Results

In 1990, commercial CPUE decreased by 41% to 6.92 MT/day fished, and the number of trips fell by 24% to 848 trips. The 1990 CPUE index was the second lowest for the 1982-1990 period and followed two years with relatively high CPUE indices (Table SF3). The number of directed trips in 1990 was higher than the 1982-1990 average reflecting an increased in the number of directed trips since 1988.

The domestic fishery for Loligo has changed over the past decade as directed foreign fishing has ended. In particular, CPUE has increased in areas 61 and 62 in recent years while CPUE has remained relatively steady in area 53 and fluctuated in areas 51, 52, and 63.

Loligo also has been retained as a higher percentage of total landed weight in trips that landed Loligo within area 61 and 62 during the late 1980s. Overall, the increase in CPUE in areas 61 and 62, the recent increase in the number of directed trips, and a higher landings ratio in area 61 and 62 may indicate a shift in fishing effort from other species (e.g., fluke, scup, black seabass) to Loligo in the mid-Atlantic region.

The 1990 all sizes, pre-recruit, and recruit indices are 24%, 55%, and 16% above the 1967-1990 means, respectively. In comparison to 1989, the 1990 all sizes and recruit indices dropped by 11% and 35%, respectively, while the 1990 pre-recruit index increased by 1%. These recent abundance indices are substantially higher than during the period of heavy foreign exploitation of this resource.

For the period 1982-1990, the Loligo recruit index and the directed CPUE index were moderately correlated ($r = 0.514$; Figure SF1). Therefore, predicting the recruit index may serve as a predictor of fishery performance.

The possibility that the recruitment index was related to the average temperature regime on the shelf (as represented by the survey average) was explored with regression analysis but this predictor explained only a very small proportion of the variation in recruit relative abundance.

Time series analysis of the recruit relative abundance index using the Box-Jenkins (1976) approach identified an autoregressive model at lag two of the log transformed and differenced series as most appropriate for these data. The lag one parameter was insignificant and only lag two was retained (AR2 coefficient -0.378; residual variance 0.591 for the log-transformed differenced series).

The one step ahead forecasts were compared to the observed values for 1989 and 1990 and a 1991 forecast was generated. The results are:

Year	Observed Index	Forecast Index (without bias connection factor)
1989	148.7	173.1
1990	95.9	103.3
1991	--	88.9

where the residual variance from the model can be used as an estimate of the standard error of the prediction. This analysis indicates that there will be a substantial reduction in recruit abundance in 1991.

SARC Analyses

The SARC calculated the proportion of zero tows in the autumn survey (Lange 1987) for comparison with previous assessments (NEFC 1990). For 1990, this value was 28.48%, which is well above the levels for the past few years of 10-20%, indicating below average abundance in 1991. Some additional analysis of the time series model was performed by the SARC as well.

Catch Projections

The time series analysis reported above are a form of catch projections for this fishery. Preliminary landings figures in the first quarter of 1991 are roughly one-half of the first quarter landings in 1990. However, April landings in 1991 are above those observed in 1990 indicating either a shift in fishing effort for Loligo or a seasonal shift in availability in 1991. Despite relatively high population abundance, it is likely that in 1991 landings and directed CPUE will be at or below levels seen in recent years.

Major Sources of Uncertainty

- High population abundance does not necessarily imply that availability of Loligo to the commercial fishery will be correspondingly high. Annual fluctuations in temperature distribution and other oceanographic variables can decrease Loligo availability to commercial fishing by increasing the spatial dispersion of the population and by altering the spatio-temporal pattern of the annual inshore/offshore migration.

- The forecasting model was constructed with relatively few data points and the prediction limits are wide.

- The effect of survey gear changes (trawl door change in 1985) has not been examined. Squid spawning aggregations are found on the bottom and it is important to consider this source of uncertainty given the reliance on the survey for this assessment.

- The stock structure of Loligo is unknown and may be a serious complication for this assessment and for application of techniques for estimating abundance and mortality such as DeLury models or the MULTIFAN method.

Recommendations

- Develop biological reference points for this species.

- Examine alternative options for surveying this species, such as a winter survey.

- Determine if the pre-recruit index has some predictive value for fishery performance.

- Include the Massachusetts inshore bottom trawl survey data in the assessment to predict inshore availability of squid.

- Continue work on the DeLury model especially on the validity of its assumptions. Apply the DeLury model to other areas and not just Area 538, which in 1990 accounted for only 9% of total landings. Other fisheries may contribute more to total F; e.g., offshore winter trawl fishery.

- Determine the feasibility of separating cohorts sampled during the trawl surveys. The species cross-over life cycle with spring and late cohorts begetting each other and being fished concurrently during the spring, complicated length frequency analyses needed for the DeLury model.

Table SF1. Annual *Loligo* squid landings (in metric tons) from the Northwest Atlantic (Cape Hatteras to Gulf of Maine) by the USA[1] and foreign fleets, 1963-90.

Year	USA	Foreign	Total
1963	1,294	0	1,294
1964	576	2	578
1965	709	99	808
1966	772	226	948
1967	547	1,130	1,167
1968	1,084	2,327	3,411
1969	899	8,643	9,542
1970	653	16,732	17,385
1971	727	17,442	18,169
1972	725	29,009	29,734
1973	1,105	36,508	37,613
1974	2,274	32,576	34,850
1975	1,621	32,180	33,801
1976	3,602	21,682	25,284
1977	1,088	15,586	16,674
1978	1,291	9,355	10,646
1979	4,252	13,068	17,320
1980	3,996	19,750	23,746
1981	2,316	20,212	22,528
1982	5,464	15,805	21,269
1983	15,943	11,720	27,663
1984	11,592	11,031	22,623
1985	10,155	6,549	16,704
1986	13,292	4,598	17,890
1987	11,475	2	11,477
1988	19,072	3	19,075
1989	23,007	5	23,012
1990	15,469	0	15,469

[1]Includes joint venture catches made by USA catcher vessels

Table SF2. Catch per unit effort (metric tons/day fished) from the directed[1] domestic *Loligo* fishery, 1982-1990.

Year	CPUE	Directed trips
1982	5.35	202
1983	11.04	949
1984	8.16	591
1985	7.96	507
1986	7.34	796
1987	7.85	612
1988	10.98	1120
1989	11.69	1115
1990	6.92	848
Mean	8.59	749

[1]Directed effort is defined as trips by vessels over 5 G.R.T. that land over 75% *Loligo*.

Table SF3. Total and pre-recruit (≤8 cm) stratified mean numbers per tow[1] of *Loligo* squid from the NEFC autumn bottom trawl surveys (mid-Atlantic to Georges Bank), 1967-90.

Year	All sizes	Pre-recruit	Recruit
1967	134.5	116.9	18.5
1968	176.5	159.9	16.6
1969	237.3	217.4	19.9
1970	85.6	79.3	6.3
1971	163.3	161.5	1.8
1972	271.4	258.5	12.9
1973	372.0	353.9	18.1
1974	251.7	233.3	18.4
1975	614.4	593.3	21.1
1976	410.9	302.5	108.4
1977	388.5	297.7	90.8
1978	144.2	93.4	50.8
1979	193.7	156.5	37.2
1980	364.1	279.8	84.3
1981	226.2	161.8	64.4
1982	310.4	256.6	53.8
1983	373.4	251.1	122.3
1984	299.8	152.2	147.6
1985	442.2	310.8	131.4
1986	453.0	360.4	92.6
1987	56.7	32.0	24.7
1988	413.7	320.0	93.7
1989	420.6	271.9	148.7
1990	371.6	275.7	95.9
Mean	299.0	237.3	61.7

[1] Stratified mean number per tow of all sizes and of individuals ≤8 cm dorsal mantle length.

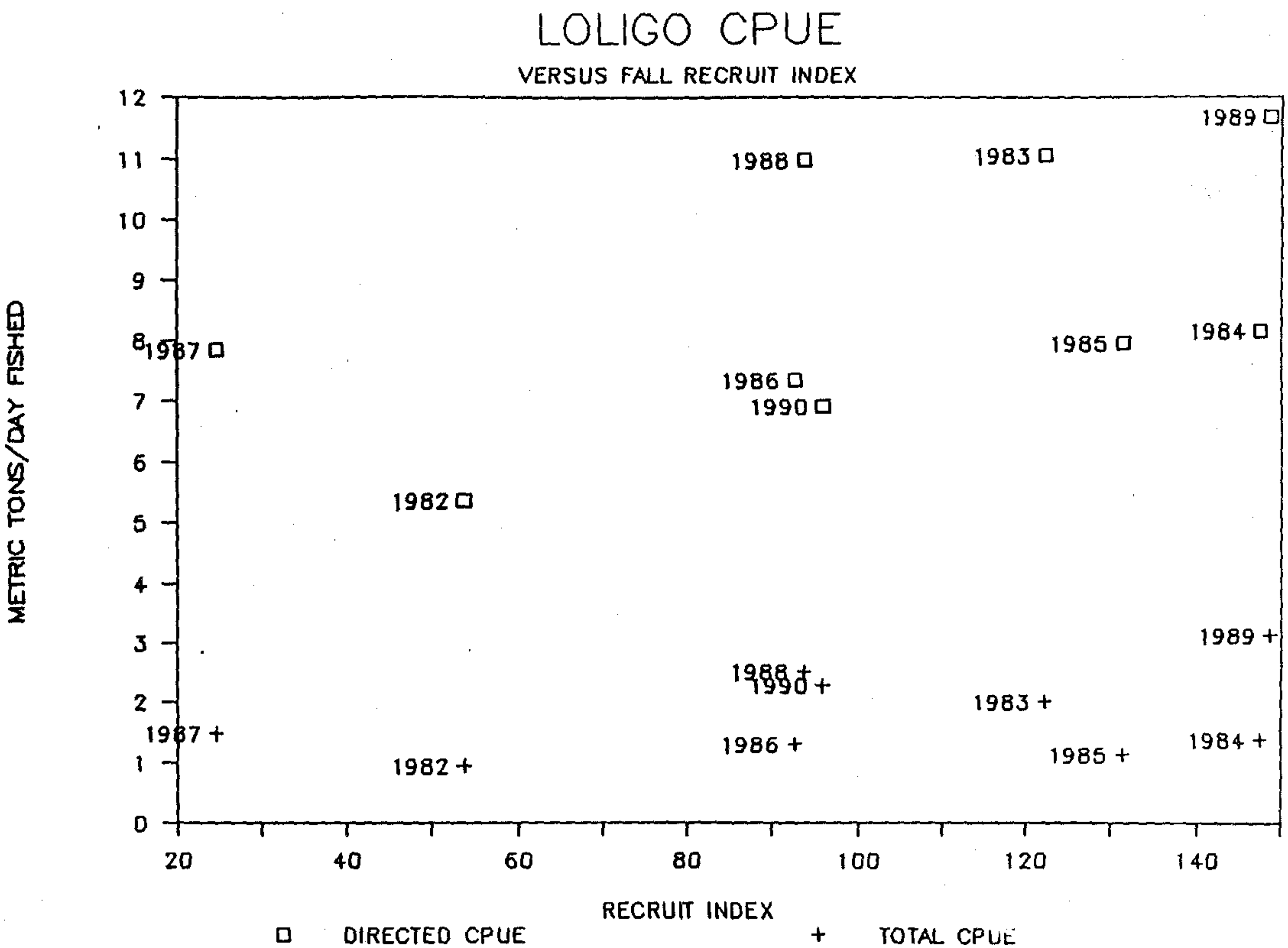


Figure SF1. Commercial catch (MT) day fished versus the autumn trawl survey index of recruits (numbers per tow). The correlation between these variables is 0.51.

ATLANTIC SEA SCALLOPS

Previous analyses of the sea scallop (Placopecten magellanicus) resource were reviewed at a Special Session of the SARC in January, 1991. The SARC concluded that these analyses were inadequate and made a number of recommendations for improvement including: (1) breakdown of Georges Bank and the Mid-Atlantic into finer scales to allow separate analyses by fishery area, (2) use of a General Linear Model (GLM) approach to estimate standardized fishing effort for each region, (3) use of a swept area method to expand up survey biomass estimates and provide upper bound estimates of fishing mortality rates, (4) aging of samples from scallop surveys to enable better separation of cohorts and thus to improve estimates of biomass and mortality rates, (5) exploration of a DeLury method to estimate annual stock sizes and fishing mortality rates, and (6) estimation of average meat weights and historic partial recruitment patterns in the commercial fishery to enable estimation of catch in number.

New analyses based on recommendations (1), (3), (5) and (6) were presented at the current meeting. It was concluded that these analyses represented a marked improvement over previous analysis, and estimates of fishing mortality and stock size derived from a DeLury model for the Delmarva sub-area of the Mid-Atlantic and the South Channel sub-area of Georges Bank were accepted as the best current estimates for evaluating stock and fishery status in these regions. Results show that both fishing mortalities and stock sizes are currently high in both sub-areas. Fishing mortality rates have been substantially greater than F_{max}throughout the period of analysis (1982-1990). The SARC concluded that, while the analysis had only been done for these two areas, it was most likely that similar partial recruitment patterns and fishing mortality rates prevailed in other areas as well.

Background

Atlantic sea scallops occur in waters from Newfoundland and Nova Scotia to North Carolina and are one of the most valuable living marine resources of the Northeast region. The fishery is conducted year round. The primary fishing gear is the scallop dredge (accounting for more than 95% of the landings in most years), with relatively small amounts taken by otter trawl.

The fishery operates in several more or less distinct areas. Georges Bank (Area 5Z) is a major fishing ground for both Canadian and American fleets, accounting for about half of the landings on average. It comprises three sub-areas: the South Channel (Areas 521, 522 &526), the Southeast Part (Area 525) and the Northern Edge and Peak (Areas 523 & 524). Canadian landings are currently only taken from the latter sub-area. The Mid-Atlantic area (Area 6) has increased in importance in recent years. It comprises the three sub-areas: New York Bight (Area 6A), Delmarva (Area 6B) and Virginia/North Carolina (Area 6C). Finally, the Gulf of Maine area in recent years has accounted for less than 10% of total landings.

In the analysis, areas of the fishery were treated separately, but no explicit assumption about stock structure was made.

Data Sources

Commercial fishery data

Total commercial landings (US and Canada) peaked at 26,671 MT (meats) in 1978, declined to a ten-year low of 9,781 mt in 1984, and then increased to 22,304 MT in 1990 (Table SG1). Landings attributed to the US fleet reached a record high of 17,174 MT in 1990, an increase of 16% over 1989. Of this total, 61% came from Georges Bank, 36% from the Mid-Atlantic and 3% from the Gulf of Maine (SAW/12/SARC/10).

Total US effort also reached a record high in 1990 with a total of 37,263 days fished, an increase of 12% over 1989. The Mid-Atlantic area experienced a reduction in days fished (-9%), while Georges Bank and the Gulf of Maine both experienced increases (33% and 16% respectively). Total days fished has doubled since 1980.

There are two sources of data on the size composition of the commercial catch. NEFC has collected shell samples from the last tow of selected commercial vessels since 1976. These shells are measured to obtain shell height frequency data which can then be used to estimate the average weight of the landings and commercial partial recruitment. Similar data have been collected from shell stocking vessels fishing in the Delmarva sub-area by the Virginia Institute of Marine Sciences, but these were not available soon enough to be incorporated in the current analyses.

Research survey data

Sea scallop research vessel surveys have been conducted by NEFC in 1975 and annually since 1977 to assess population relative abundance, size composition and recruitment patterns (SAW/12/SARC/13). The 1990 survey indicates that scallop abundance in both the Mid-Atlantic and Georges Bank areas is at or near record-high levels (Table SG2). Overall, both areas appear to have experienced strong recruitment in recent years (particularly the 1986 and 1987 years classes); however, there is considerable variation in the relative sizes of the pre-recruit indices between the sub-areas within each area. All areas and sub-areas were dominated by small recruits (those with meat counts in the range 80-40 per lb) which accounted for 64% of the harvestable biomass (scallops < 80 meat count) overall.

The survey relative abundance indices and length composition information are used for calculating estimates of swept area biomass, and were the main input, along with landings data, to the MULTIFAN and DeLury analysis procedures outlined below.

Other input data

The natural mortality rate was assumed to be 0.1. Growth parameters were derived from Posgay and Norman (1958) and gear selectivity estimates were from Serchuk and Smolowitz (1980).

Methodology

Methods of estimating mortality rates and abundance

Swept area estimates:

Survey data were used to estimate swept area biomass for sub-areas of the fishery because it was believed that it might be possible to use these data to provide upper bounds on estimates of fishing mortality rates (by assuming 100% efficiency of the survey gear). However, the estimates were not useful for this purpose because landings were often higher than the estimated biomass and fishing mortality rate was unbounded (SAW/12/SARC/8). The SARC determined that, because this fishery relies on new recruitment in each year for the bulk of the landings and, additionally, survey swept area estimates are likely to under estimate the stock available to the fleet, useful estimates of fishing mortality rates cannot be made in this way.

MULTIFAN estimates:

The size composition data collected on NEFC sea scallop surveys were analyzed using MULTIFAN, a recently developed mixture of distributions method for analyzing length-frequency data (Fournier et al 1990). Growth parameters and estimated size at age were provided for three fishing areas: Delmarva, the South Channel and the New York Bight (SAW/12/SARC/11). Growth parameter estimates gave mean size at age estimates which were generally in good agreement with previous estimates from the literature (Posgay and Norman 1958) and with the limited amount of age information available for scallops. However, there was high variability in mean size at age between cohorts as determined by MULTIFAN.

In order to account for the apparent variation in growth rates, it was necessary to run MULTIFAN with groups of only 1-2 survey size composition samples at a time. This procedure was used to split the survey data into annual indices of the abundance of new recruits (age 3) and full recruits (age 4+) for subsequent use in the DeLury model.

DeLury model estimates:

A modified DeLury model developed by the Sea Scallop Working Group was used to provide estimates of stock size and fishing mortality for the Delmarva and South Channel fishing areas over the periods 1982-90 and 1981-90 respectively (SAW/12/SARC/9). The main inputs (Table SG3) to the model were:

1) commercial landings by survey year (July-June);

2) mean weights of the landings estimated from the NEFC last tow samples;

3) a time series of relative numbers of new recruits (age 3) and full recruits (ages 4+) estimated from MULTIFAN runs on survey data;

4) annual estimates of the selectivity of recruits (age 3) to the survey gear derived from annual mean size estimates of recruits and the results in Serchuk and Smolowitz (1980);

5) annual estimates of the average partial recruitment of new recruits (age 3) to the commercial fishery (It was assumed that partial recruitment increased linearly from 0 at the average size for a scallop of age 3.0 to 1 at the average size for a scallop of age 4.0, assuming growth parameters derived by Posgay and Norman, 1958); and

6) the actual mean size of age 3 scallops in each year as estimated from MULTIFAN runs on survey data.

Detailed descriptions of the model structure and estimation procedure are contained in SAW/12/SARC/9. Outputs include numbers of new recruits, numbers of full recruits, fishing mortality rates on new recruits and full recruits, survey catchabilities on full recruits, and diagnostics such as residuals, coefficients of variation of parameter estimates and correlations between parameters.

Assessment Results

The SARC concluded that the DeLury analysis provided a statistically based method for the assessment of sea scallops, and accepted the estimates of fishing mortality and stock size calculated for the Delmarva and South Channel sub-areas (Table SG4). The model performed well on both sets of data, although the coefficients of variation of the South Channel stock size parameter estimates were generally higher (50-70%) than for Delmarva (30%). The SARC calculated the variance of the estimates of total mortality rate from the individual parameter estimates and found a coefficient of variation of the order of 35% for these estimates.

The analysis shows that fishing mortality rates in both areas have generally been high (larger than F=1.0 and sometimes larger than F=2.0) throughout the time series. Fishing mortality appears to have increased over time in the Delmarva sub-area, while being consistently high but without trend in the South Channel sub-area.

Despite these high fishing mortality rates, the current abundance (1990) of fully recruited scallops appears to have increased to the highest level in the time series in Delmarva. The abundance of new recruits is extremely high in the South Channel, but the stock of fully recruited scallops is near average levels. Biomass estimates were not calculated pending further analysis of data on mean weights from the commercial shell height samples.

The survey relative abundance indices and length frequency data indicate that the level of fishing mortality rates and partial recruitment patterns for scallops in the other subareas are similar to those estimated for the South Channel and Delmarva.

A further result from the DeLury analysis was that the survey catchability of fully recruited scallops in Delmarva was almost twice that for the South Channel. This agrees with previous work on the efficiency of the gear in the two areas, which have markedly different bottom types.

SARC Analyses

Yield per recruit analysis was conducted separately for the Delmarva and South Channel sub-areas. Estimates of partial recruitments for age 3 scallops were obtained by averaging the partial recruitments used in the DeLury model over the years 1987-90 inclusive. Weights at age were based on growth parameters from Posgay and Norman (1958), adding 0.5 to t in the von Bertalanffy equation to obtain mid-year estimates. Resulting estimates of $F_{0.1}$ and F_{max} were 0.11 and 0.22 respectively for the Delmarva sub-area and 0.12 and 0.23 for the South Channel (Figure SG1). These estimates are similar to those from previous YPR analyses.

Estimated fishing mortality rates have been several times higher than either of the reference points from YPR analysis throughout the time period included in the analysis. The current level of fishing mortality results in more than a 60% loss in yield per recruit. There is no approved definition of overfishing at this time. Due to the extremely high Fs, the SARC concluded that average recorded landings are not likely to be a valid estimate of long term sustainable yield for scallops since landings have not been stable (without trends) and do not represent equilibrium conditions.

The SARC also performed a sensitivity analysis of the DeLury model with respect to the assertion that there has been substantial under-reporting of landings in recent years. An additional run was made in which the landings in last three years were doubled. The resulting estimates of the total mortality rate on the stock were very similar to the original analysis. The exploitation pattern was shifted such that the estimates of fishing mortality on younger scallops increased, and that on older scallops decreased. The estimates of stock size also increased. The SARC concluded that the DeLury estimates of the basic pattern and level of fishing mortality was relatively robust to misreporting problems.

Major Sources of Uncertainty

The sources of uncertainty that were of greatest concern to the SARC were:

- The high coefficients of variation of the parameter estimates, particularly for the South Channel area. Note however, that if the variance is calculated for the stock size and total mortality rate estimates (using the underlying parameter estimates and their variances) the resultant CVs for Delmarva are around 35%, somewhat lower than the individual parameter estimates and relatively precise given the high mortality rates.

- The possibility of multiple spawnings per year in the Mid-Atlantic which complicates the interpretation of spawning biomass. There is insufficient maturity data for scallops to calculate spawning biomass per recruit curves at this time.

- The possibility that catch numbers have been under-estimated due to small scallops being under-represented in last-tow samples. This is not problematic if there is no trend in the extent of under-representation since the difference will be accounted for in the catchability coefficient; however, a trend of increasing under-representation of small scallops in recent years would likely result in over-estimation of fishing mortality and under-estimation of stock size. The sensitivity analysis showed that the estimation procedure is generally robust with respect to misreporting or under estimation of the landings; however, further sensitivity studies are needed.

Recommendations

The SARC recommends that:

- The DeLury model presented at this meeting should be used to conduct parallel analyses for the other sub-areas of Georges Bank and the Mid-Atlantic, and a pooled analysis including all areas should also be attempted.

- Alternative biological reference points such as F_{rep} or F_{med} should be investigated using the pooled analysis extended back in time.

The SARC also reiterated its previous recommendations to:

- Routinely age the samples from the scallop surveys so as to provide a more rigorous method for splitting the survey length-frequency distributions to obtain indices of abundance for pre-recruits and full recruits.

- Sample (and age) the commercial catch so as to provide estimates of commercial partial recruitment patterns and the average meat weight in the landings. These are requisite data for estimating catch in number, an important input to the DeLury model. Ideally, sampling of the commercial catch should be conducted at sea, but if this is not feasible a port sampling program for meats could suffice. The current sampling program needs to be evaluated in this regard.

- The Sea Scallop Working Group should resolve differences between NEFC and NEFMC in the calculation of total landings.

- A General Linear Model (GLM) approach should be used to estimate standardized fishing effort for each region.

Table SG1.

United States and Canadian sea scallop landings (metric tons, meats) from the Northwest Atlantic (NAFO Subarea 5 and Statistical Area 6), 1887 - 1990.

Year	USA[1]	Year	USA	CANADA[2]	Total
1887	112	1947	6,647		6,647
1888 *	91	1948	7,546		7,546
1889	141	1949	8,299		8,299
1892	53	1950	9,063		9,063
1897	435	1951	8,503	91	8,594
1898	156	1952	8,451	91	8,542
1899 *	24	1953	10,713	136	10,849
1900 *	79	1954	7,997	91	8,088
1901	286	1955	10,036	136	10,172
1902	61	1956	9,102	317	9,419
1903 *	62	1957	9,523	771	10,294
1904	216	1958	8,608	1,179	9,787
1905	200	1959	11,178	2,378	13,556
1906 *	255	1960	12,065	3,470	15,535
1907 *	236	1961	12,456	4,565	17,021
1908	834	1962	11,174	5,715	16,889
1909 *	843	1963	9,038	5,898	14,936
1910 *	919	1964	7,704	5,922	13,626
1911 *	663	1965	9,105	7,052	16,157
1912 *	842	1966	7,237	7,669	14,906
1913 *	353	1967	4,646	5,025	9,671
1914 *	386	1968	5,473	5,243	10,716
1916 *	266	1969	3,363	4,320	7,683
1919	89	1970	2,613	4,097	6,710
1921	38	1971	2,593	3,908	6,501
1924	154	1972	2,655	4,177	6,832
1926	506	1973	2,401	4,223	6,624
1928	216	1974	2,722	6,137	8,859
1929	1,130	1975	4,422	7,414	11,836
1930	1,111	1976	8,721	9,780	18,501
1931	1,058	1977	11,103	13,091	24,194
1932	1,517	1978	14,482	12,189	26,671
1933	2,009	1979	14,256	9,207	23,463
1935	1,955	1980	12,566	5,239	17,805
1937	3,989	1981	11,742	8,018	19,760
1938	4,041	1982	9,044	4,330	13,374
1939	4,440	1983	8,707	2,895	11,602
1940	3,467	1984	7,739	2,042	9,781
1941 #	3,622	1985	6,742	3,851	10,593
1942	3,258	1986	8,661	4,705	13,366
1943	2,508	1987	13,227	6,810	20,037
1944	2,209	1988	13,198	4,405	17,603
1945	2,590	1989	14,776	4,676	19,452
1946	5,326	1990	17,174	5,130	22,304

[1] USA landings: 1887-1960 from Lyles (1969); 1961-1975 from Fishery Statistics of the United States; 1963-1982 from ICNAF and NAFO Statistical Bulletins; 1964-1990 from Detailed Weighout Data, Northeast Fisheries Center, Woods Hole, Mass.

[2] Canadian landings: 1951-1958 from ICNAF Statistical Bulletins and Caddy (1975); 1953-1988 from Mohn et al. (1989) for Georges Bank and from ICNAF/NAFO Bulletins for Gulf of Maine and Mid-Atlantic; 1989 from NAFO SCS Doc. 90/21; 1990 from DFO, Statistics Branch, Halifax.

* Maine landings only - from Baird (1956).

USA landings for 1941 from O'Brien (1961).

Table SG2a.

USA sea scallop research survey relative abundance indices (standardized stratified mean number and mean weight per tow), (meats only, kg), mean shell height (mm), mean meat weight (g) per scallop, and average meat count (number of scallop meats per pound) of sea scallops from NEFC surveys in the Mid-Atlantic, 1975, 1977-1990. Data are presented by principal scallop regions in the Mid-Atlantic[1]. Survey indices are presented for pre-recruit (<70 mm shell height), recruit (≥70 mm shell height), and total scallops per tow.

Area	Year	No. of Tows	Standardized Stratified Mean Number Per Tow			Standardized Stratified Mean Weight (kg) Per Tow[2]			Mean Shell Height	Average Meat Count
			Pre-recruit	Recruit	Total	Pre-recruit	Recruit	Total		
New York Bight	1975	28	39.4	34.7	74.1	0.10	0.62	0.72	75.3	46.9
	1977	101	1.4	56.7	58.1	<0.01	1.03	1.03	98.6	25.6
	1978	116	3.3	52.7	56.0	0.01	1.15	1.16	102.8	21.9
	1979	120	5.3	17.6	22.9	0.01	0.43	0.44	93.6	23.7
	1980	121	15.4	15.2	30.6	0.02	0.36	0.38	75.5	35.7
	1981	117	18.8	19.0	37.8	0.03	0.29	0.32	67.7	53.5
	1982	134	10.9	20.9	31.8	0.02	0.33	0.35	78.4	41.2
	1983	136	11.5	14.0	25.5	0.03	0.29	0.32	80.3	36.6
	1984	142	17.4	18.4	35.8	0.03	0.29	0.32	69.2	51.0
	1985	137	47.4	30.9	78.3	0.10	0.43	0.53	65.6	67.1
	1986	152	53.2	49.3	102.5	0.13	0.65	0.78	69.6	59.9
	1987	154	94.5	46.0	140.5	0.18	0.58	0.76	61.7	83.7
	1988	154	75.9	100.5	176.4	0.11	1.25	1.36	68.6	58.9
	1989	157	168.6	81.8	250.4	0.25	0.90	1.15	56.4	99.1
	1990	148	121.1	92.8	213.9	0.35	0.88	1.23	67.2	78.7
Delmarva	1975	15	36.2	24.0	60.2	0.11	0.44	0.55	75.2	49.3
	1977	10	10.7	47.5	58.2	0.03	0.91	0.94	92.2	28.1
	1978	45	27.3	75.8	103.2	0.09	1.58	1.67	91.6	28.0
	1979	43	25.4	64.6	90.0	0.04	0.95	0.99	78.8	41.2
	1980	43	81.1	35.9	117.0	0.13	0.68	0.81	63.3	65.7
	1981	41	4.7	14.3	19.0	0.01	0.32	0.33	90.3	26.2
	1982	44	10.0	18.6	28.6	0.04	0.43	0.47	89.8	27.8
	1983	49	25.7	16.5	42.2	0.09	0.37	0.46	77.0	41.7
	1984	52	19.8	19.3	39.1	0.03	0.38	0.41	69.8	43.7
	1985	54	70.4	35.8	106.2	0.15	0.43	0.58	58.9	82.5
	1986	62	123.5	83.5	207.0	0.37	0.93	1.30	68.5	72.3
	1987	61	52.9	59.5	112.4	0.16	0.74	0.90	74.1	56.7
	1988	62	75.9	39.1	115.0	0.15	0.62	0.77	64.6	67.9
	1989	62	113.1	97.2	210.3	0.24	1.09	1.33	67.5	71.6
	1990	62	27.7	80.9	108.6	0.06	0.87	0.93	76.9	53.0
Virginia-No. Carolina	1975	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1977	1	0.0	10.0	10.0	0.00	0.23	0.23	108.0	20.0
	1978	3	15.3	50.3	65.6	0.06	1.10	1.16	91.8	25.7
	1979	3	23.7	22.7	46.4	0.04	0.37	0.41	71.7	51.3
	1980	3	6.6	39.0	45.6	0.02	0.59	0.61	87.6	34.1
	1981	3	0.9	7.6	8.5	<0.01	0.20	0.20	107.7	18.8
	1982	7	0.4	3.7	4.1	<0.01	0.12	0.12	111.5	15.8
	1983	8	25.8	11.7	37.5	0.10	0.36	0.46	78.1	37.2
	1984	9	0.2	14.6	14.8	<0.01	0.27	0.27	98.7	25.3
	1985	10	1.7	7.3	9.0	<0.01	0.23	0.23	104.8	17.8
	1986	10	5.6	1.8	7.4	<0.02	0.04	0.06	69.1	55.9
	1987	10	0.1	2.1	2.2	<0.01	0.04	0.04	93.4	28.3
	1988	10	3.1	11.0	14.1	0.01	0.21	0.22	89.8	28.9
	1989	10	35.7	5.9	41.6	0.07	0.13	0.20	57.9	92.9
	1990	6	36.5	93.1	129.6	0.07	0.88	0.95	73.2	61.7
Mid-Atlantic (All Areas)	1975	43	38.8	32.6	71.4	0.10	0.59	0.69	75.3	47.2
	1977	112	2.8	55.1	57.9	0.01	1.00	1.01	97.7	25.9
	1978	164	7.8	56.8	64.6	0.02	1.23	1.25	99.4	23.4
	1979	166	9.1	26.2	35.3	0.02	0.52	0.54	86.5	29.8
	1980	167	27.1	19.2	46.3	0.04	0.42	0.46	70.1	45.8
	1981	161	16.1	18.0	34.1	0.02	0.30	0.32	70.1	48.2
	1982	185	10.6	20.3	30.9	0.03	0.34	0.37	80.4	38.1
	1983	193	14.3	14.4	28.7	0.04	0.30	0.34	79.4	37.8
	1984	203	17.6	18.5	36.1	0.02	0.31	0.33	69.5	49.2
	1985	201	51.0	31.5	82.5	0.11	0.43	0.54	64.1	69.8
	1986	224	65.2	54.8	120.0	0.17	0.69	0.86	69.3	63.3
	1987	225	85.7	47.9	133.6	0.17	0.61	0.78	63.6	78.0
	1988	226	74.9	88.3	163.2	0.12	1.12	1.24	68.1	59.9
	1989	229	156.9	83.6	240.5	0.24	0.93	1.17	58.1	93.5
	1990	216	103.2	90.6	193.8	0.29	0.88	1.17	68.2	74.9

[1] New York Bight: Strata 22-31, 33-35; Delmarva: Strata 10-11, 14-15, 18-19; Va-NC: Strata 6-7.

[2] Mean meat weight derived by applying the 1977-1982 USA Mid-Atlantic research survey sea scallop shell height meat weight equation, ln Meat Weight (g) = -12.1628 + 3.2539 ln Shell Height (mm) (n = 11943, r = 0.98), to the survey shell height frequency distributions.

Table SG2b.

USA sea scallop research survey relative abundance indices (standardized stratified mean number and mean weight per tow), [meats only, kg], mean shell height (mm), mean meat weight (g) per scallop, and average meat count (number of scallop meats per pound) of sea scallops from NEFC surveys on Georges Bank, 1975, 1977-1990. Data are presented by principal scallop regions on Georges Bank[1]. Survey indices are presented for pre-recruit (<70 mm shell height), recruit (≥70 mm shell height), and total scallops per tow.

Area	Year	No. of Tows	Standardized Stratified Mean Number Per Tow			Standardized Stratified Mean Weight (kg) Per Tow[2]			Mean Shell Height	Average Meat Count
			Pre-recruit	Recruit	Total	Pre-recruit	Recruit	Total		
South Channel	1975	58	45.1	29.9	75.0	0.11	0.81	0.92	76.4	37.0
	1977	30	6.3	89.1	95.4	0.02	1.94	1.96	101.3	22.1
	1978	46	7.7	49.7	57.4	0.02	1.15	1.17	101.2	22.2
	1979	47	6.8	88.2	95.0	0.01	1.53	1.54	93.2	28.0
	1980	40	79.7	30.2	109.9	0.12	0.55	0.67	58.2	74.6
	1981	56	15.5	36.5	52.0	0.03	0.65	0.68	80.5	34.8
	1982	61	213.8	53.0	266.8	0.49	0.67	1.16	58.6	103.9
	1983	69	19.0	55.8	74.8	0.06	0.77	0.83	81.4	41.0
	1984	69	13.6	17.7	31.3	0.03	0.36	0.39	77.3	36.7
	1985	77	40.3	47.3	87.6	0.11	0.76	0.87	75.0	45.7
	1986	68	115.3	37.0	152.3	0.24	0.58	0.82	59.5	84.2
	1987	86	84.6	56.1	140.7	0.17	0.72	0.89	63.6	71.6
	1988	91	32.5	36.0	68.5	0.08	0.46	0.54	70.6	57.7
	1989	88	21.7	15.1	36.8	0.06	0.27	0.33	72.0	50.5
	1990	76	258.8	49.9	308.7	0.54	0.60	1.14	55.9	122.5
Southeast Part	1975	21	1.8	38.4	40.2	<0.01	1.02	1.02	110.3	17.8
	1977	21	3.2	27.2	30.4	0.01	0.68	0.69	103.6	20.0
	1978	18	2.2	27.1	29.3	<0.01	0.93	0.93	117.2	14.2
	1979	20	7.7	21.2	28.9	0.01	0.71	0.72	99.4	18.2
	1980	20	21.5	41.7	63.2	0.03	0.71	0.74	78.2	38.8
	1981	19	1.4	19.4	20.8	<0.01	0.46	0.46	102.5	20.5
	1982	22	0.8	9.8	10.6	<0.01	0.32	0.32	113.5	15.2
	1983	20	11.3	9.2	20.5	0.02	0.25	0.27	78.1	34.0
	1984	20	4.6	12.9	17.5	0.01	0.23	0.24	85.7	33.0
	1985	28	9.1	11.8	20.9	0.02	0.22	0.24	75.3	39.9
	1986	32	28.9	20.6	49.5	0.05	0.41	0.46	66.2	48.5
	1987	32	23.1	39.6	62.7	0.06	0.60	0.66	79.0	42.8
	1988	32	1.4	16.1	17.5	<0.01	0.32	0.32	96.9	24.6
	1989	31	23.6	11.8	35.4	0.07	0.23	0.30	70.2	54.4
	1990	32	1.6	8.4	10.0	<0.01	0.15	0.15	88.7	30.3
No. Edge & Peak	1975	51	83.8	135.9	219.7	0.21	2.02	2.23	78.1	44.7
	1977	71	66.1	384.8	450.9	0.23	5.06	5.30	85.3	38.6
	1978	76	177.7	372.9	550.6	0.31	7.60	7.91	85.1	31.6
	1979	153	72.0	257.9	329.9	0.21	4.46	4.67	87.2	32.1
	1980	311	665.7	143.7	809.4	0.91	2.05	2.96	52.4	123.9
	1981	101	277.4	405.7	683.1	0.63	3.79	4.42	68.9	70.1
	1982	80	40.9	65.3	106.2	0.12	0.95	1.07	78.1	45.1
	1983	82	48.2	37.1	85.3	0.08	0.67	0.75	68.2	51.9
	1984	82	293.8	54.0	347.8	0.29	0.84	1.13	46.7	139.3
	1985	108	84.5	192.2	276.7	0.25	1.85	2.10	73.9	59.6
	1986	216	173.0	195.6	368.6	0.39	2.59	2.98	72.0	56.2
	1987	118	150.2	122.2	272.4	0.30	1.61	1.91	66.9	64.6
	1988	119	99.3	124.4	223.7	0.23	1.53	1.76	70.5	57.6
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990[4]	106	223.8	236.0	459.8	0.42	2.68	3.10	66.4	67.4
Georges Bank (All Areas)	1975	130	51.7	74.6	126.3	0.13	1.34	1.47	79.9	39.0
	1977	122	34.3	218.3	252.6	0.12	3.18	3.30	87.6	34.7
	1978	140	79.7	184.0	263.7	0.14	3.88	4.02	87.1	29.8
	1979	220	36.6	152.3	188.9	0.10	2.70	2.80	88.6	30.6
	1980	371	377.4	92.3	469.7	0.52	1.37	1.89	53.4	112.6
	1981	176	97.2	152.4	249.6	0.22	1.62	1.84	70.6	61.5
	1982	163	91.0	51.2	142.2	0.22	0.74	0.96	66.5	66.9
	1983	171	31.9	38.2	70.1	0.06	0.63	0.69	73.4	46.3
	1984	171	148.7	34.6	183.3	0.15	0.57	0.72	49.1	114.9
	1985	213	56.3	111.6	167.9	0.17	1.19	1.36	74.1	56.2
	1986	316	129.9	123.0	252.9	0.28	1.68	1.96	70.1	58.5
	1987	236	105.5	85.4	190.9	0.21	1.14	1.35	66.9	64.3
	1988	242	59.5	75.6	135.1	0.14	0.96	1.10	71.2	55.9
	1989[3]	119	22.4	14.0	36.4	0.06	0.26	0.32	71.4	52.3
	1990[4]	214	193.6	127.3	320.9	0.38	1.47	1.85	63.0	78.7

[1] South Channel: Strata 46-47, 49-55; Southeast Part: Strata 58-60; No. Edge & Peak: Strata 61-662, 71-72, and 74.

[2] Mean meat weight derived by applying the 1978-1982 USA Georges Bank research survey sea scallop shell height meat weight equation, ln Meat Weight (g) = -11.7656 + 3.1693 ln Shell Height (mm) (n = 5863, r = 0.98), to the survey shell height frequency distributions.

[3] Combined South Channel and Southeast Part regions only.

[4] Stratum 72 not sampled, excluded from analyses.

Table SG2c.

USA sea scallop research survey relative abundance indices (standardized stratified mean number and mean weight per tow), [meats only, kg], mean shell height (mm), mean meat weight (g) per scallop, and average meat count (number of scallop meats per pound) of sea scallops from NEFC surveys in the USA and Canadian sectors of Georges Bank, 1985-1990. Data are presented for the USA and Canadian Northern Edge and Peak regions of Georges Bank[1], and the entire USA sector of Georges Bank. Survey indices are presented for pre-recruit (<70 mm shell height), recruit (≥70 mm shell height), and total scallops per tow.

Area	Year	No. of Tows	Standardized Stratified Mean Number Per Tow: Pre-recruit	Recruit	Total	Standardized Stratified Mean Weight (kg) Per Tow[2]: Pre-recruit	Recruit	Total	Mean Shell Height	Average Meat Count
USA No. Edge & Peak	1985	67	21.8	26.6	48.4	0.06	0.39	0.45	72.2	48.9
	1986	70	45.6	28.6	74.2	0.13	0.48	0.61	70.4	55.2
	1987	71	62.0	54.6	116.6	0.12	0.73	0.85	67.1	62.1
	1988	71	65.8	60.9	126.7	0.15	0.77	0.92	66.4	62.6
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990[4]	65	66.9	196.8	263.7	0.22	1.83	2.05	75.8	58.3
Canada No. Edge & Peak	1985	41	186.0	460.3	646.3	0.58	4.20	4.78	74.1	61.3
	1986	146	379.6	466.0	845.6	0.80	6.01	6.81	72.3	56.3
	1987	47	293.0	231.7	524.7	0.59	3.04	3.63	66.9	65.6
	1988	48	153.7	227.1	380.8	0.36	2.77	3.13	72.8	55.3
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990	41	431.7	287.9	719.6	0.68	3.80	4.48	61.9	72.9
USA Sector of Georges Bank	1985	172	26.5	31.8	58.3	0.07	0.50	0.57	74.2	46.4
	1986	170	61.3	28.9	90.2	0.14	0.49	0.63	64.4	64.9
	1987	189	62.6	51.9	114.5	0.12	0.70	0.82	66.8	63.0
	1988	194	38.0	40.8	78.8	0.09	0.54	0.63	69.4	56.6
	1989[3]	119	22.4	14.0	36.4	0.06	0.26	0.32	71.4	52.3
	1990[4]	173	135.2	87.8	223.0	0.31	0.89	1.20	63.9	84.1

[1] USA No. Edge & Peak: Strata 61, 621, 631, 651, 662, 71, 72, and 74.
Canada No. Edge & Peak: Strata 622, 632, 64, 652, and 662.

[2] Mean meat weight derived by applying the 1978-1982 USA Georges Bank research survey sea scallop shell height meat weight equation, ln Meat Weight (g) = -11.7656 + 3.1693 ln Shell Height (mm) (n = 5863, r = 0.98), to the survey shell height frequency distributions.

[3] Combined South Channel and Southeast Part regions only.

[4] Stratum 72 was excluded from the analysis since it was not sampled in 1990.

Table SG3. Input data for DeLury Analysis.

a)

South Channel Stock

CALENDAR YEAR	LANDINGS (mt) Jan-Jun	Jul-Dec	MEAN WEIGHT (g) Jan-Jun	Jul-Dec	CATCH NUMBERS (millions) Jan-Jun	Jul-Dec
1981	1004.600	1836.500	16.565	17.194	60.646306	106.812379
1982	1536.100	1790.100	23.122	22.259	66.433990	80.423209
1983	1109.100	1306.800	23.875	24.789	46.454256	52.716293
1984	733.900	884.200	25.515	26.948	28.763472	32.811219
1985	514.000	1025.800	18.872	26.879	27.236839	38.163480
1986	1123.500	1576.500	16.701	20.413	67.271421	77.229818
1987	826.400	1560.800	15.734	19.274	52.524867	80.979138
1988	1474.200	1634.900	20.009	19.921	73.677214	82.068349
1989	803.200	1956.000	23.297	17.868	34.476838	109.468217
1990	1391.700	2571.900	16.036	19.133	86.787064	134.425013

SURVEY YEAR	-- INDICES OF ABUNDANCE -- RECRUITS	FULLY-RECRUITED	TOTAL CATCH (millions)
1981	14016	35195	173.246369
1982	205585	60521	126.877465
1983	13718	61073	81.479765
1984	12912	17477	60.048057
1985	32540	52964	105.434901
1986	114673	29629	129.754685
1987	68833	69696	154.656351
1988	23628	44160	116.545187
1989	19360	17401	196.255281
1990	238455	69632	

Note that a survey year (SY) begins in July and ends the following June, e.g. SY1987 is 1 JUL 87 thru 30 JUNE 88.

b)

Delmarva Stock

CALENDAR YEAR	LANDINGS (mt) Jan-Jun	Jul-Dec	MEAN WEIGHT (g) Jan-Jun	Jul-Dec	CATCH NUMBERS (millions) Jan-Jun	Jul-Dec
1982	135.300	221.100	28.209	32.326	4.796393	6.839611
1983	112.400	184.000	29.425	33.263	3.819816	5.531605
1984	364.700	579.900	27.171	22.901	13.422448	25.322259
1985	276.500	248.300	26.491	26.155	10.437704	9.493586
1986	429.000	383.900	20.465	21.925	20.962722	17.509692
1987	1079.500	1719.600	17.829	19.681	60.548442	87.372721
1988	1566.600	1120.300	21.042	23.899	74.449683	46.876438
1989	1322.400	775.200	19.632	20.252	67.359413	38.277890
1990	1910.000	972.800	14.624	19.904	130.609007	48.874107

SURVEY YEAR	-- INDICES OF ABUNDANCE -- RECRUITS	FULLY-RECRUITED	TOTAL CATCH (millions)
1982	12449	16099	10.659427
1983	30655	11497	18.954054
1984	13512	17496	35.759964
1985	59856	13127	30.456308
1986	153737	46594	78.058134
1987	62297	47367	161.822404
1988	77143	34785	114.235852
1989	113719	96160	168.886897
1990	22281	85974 .	.

Note that a survey year (SY) begins in July and ends the following June, e.g. SY1987 is 1 JUL 87 thru 30 JUNE 88.

Indices of abundance are from the NEFC scallop survey. They are assumed to be proportional to stock abundance of July 1st. The survey size composition is "aged" using MultiFan to develop indices for recruits (age 3) and for the fully recruited ages (ages 4+).

Table SG4. DeLury Analysis Estimates of Stock Size and Mortality Rates for Scallops.

a) South Channel

SURVEY YEAR	STOCK SIZE ESTIMATES (millions - July 1) RECRUITS	FULLY-RECRUITED	Z on ages 3+	F on age 3	F on ages 4+
1981	143.029	101.087	1.10	0.30	1.99
1982	353.132	81.570	1.10	0.72	2.18
1983	42.893	145.015	1.04	0.37	1.11
1984	58.739	66.618	0.50	0.19	0.58
1985	103.273	76.039	1.08	0.53	1.60
1986	275.805	60.720	0.90	0.58	1.76
1987	201.000	137.344	1.17	0.42	2.02
1988	88.108	104.971	1.25	0.38	1.80
1989	223.044	55.325	1.00	0.51	2.45
1990	1149.707	102.700			

Note that the recruit population estimate for the last year (1990) is NOT a least squares estimate. It is calculated from the observed survey index, the least squares estimate of q, and the calculated selectivity.

b) Delmarva

SURVEY YEAR	STOCK SIZE ESTIMATES (millions - July 1) RECRUITS	FULLY-RECRUITED	Z on ages 3+	F on age 3	F on ages 4+
1982	15.063	14.520	0.75	0.45	0.87
1983	36.288	13.918	0.74	0.51	0.97
1984	25.316	24.067	1.33	0.58	1.92
1985	67.311	13.060	0.59	0.45	0.67
1986	150.792	44.649	0.90	0.66	1.25
1987	117.550	79.582	1.74	1.13	2.40
1988	175.372	34.526	0.85	0.41	2.43
1989	204.803	90.092	1.06	0.37	2.31
1990	48.195	101.809			

Note that the recruit population estimate for the last year (1990) is NOT a least squares estimate. It is calculated from the observed survey index, the least squares estimate of q, and the calculated selectivity.

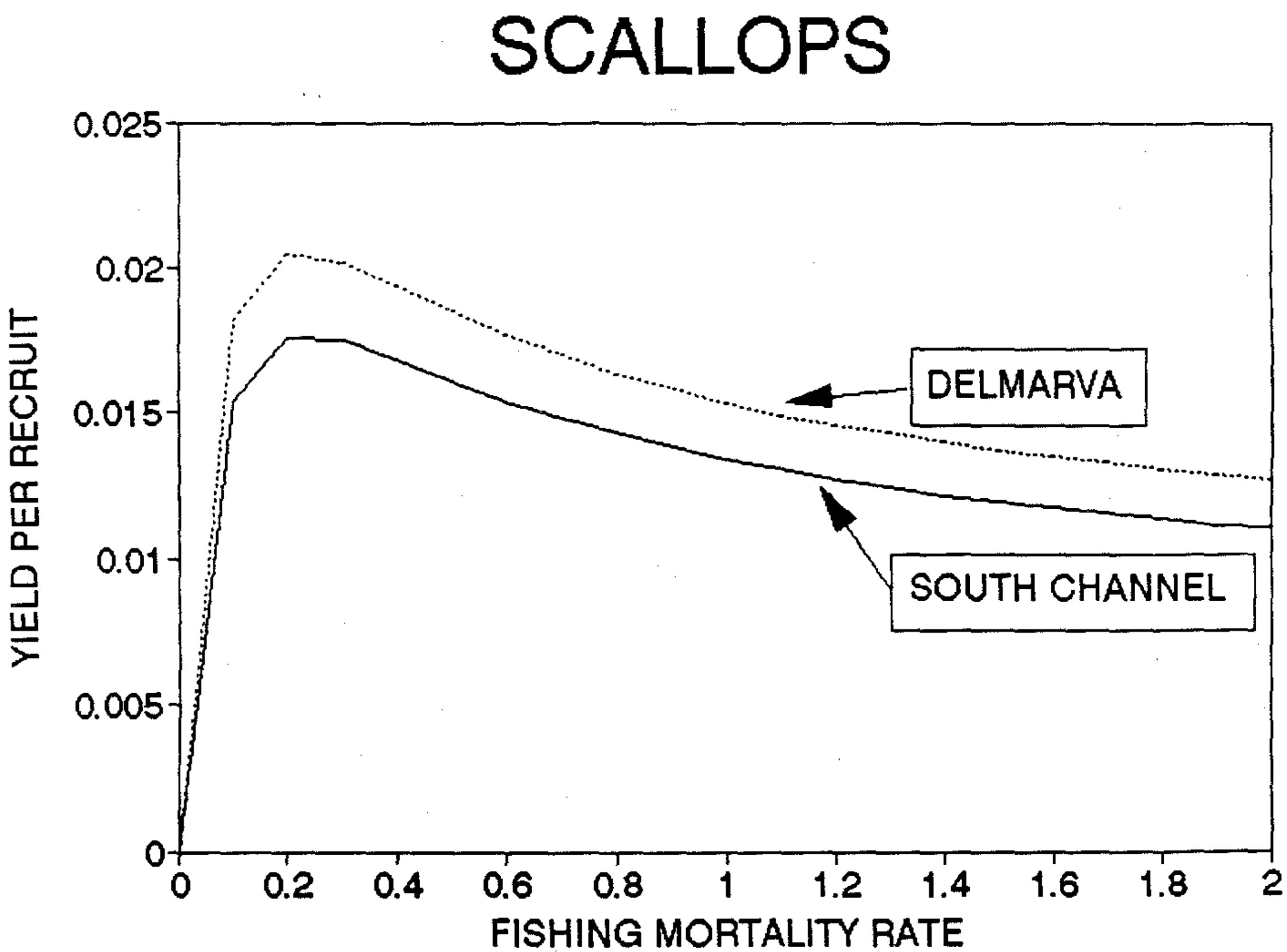


Figure SG1. Yield per recruit analyses for Atlantic sea scallop from Delmarva and the South Cannel area of Georges Bank.

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ADVISORY REPORT ON STOCK STATUS

INTRODUCTION

The **Advisory Report on Stock Status** is a major product of the Northeast Regional Stock Assessment Workshop. It summarizes the technical information contained in the **Stock Assessment Review Committee (SARC) Consensus Summary of Assessments** and is intended to serve as scientific advice for fishery managers on resource status.

An important aspect of scientific advice on fishery resources is the determination of whether a stock is currently over-, fully-, or under-exploited. Since these categories specifically refer to the act of fishing, they are best thought of in terms of exploitation rates relative to reference values such as the replacement rate of fishing mortality, F_{rep},or the rate of fishing mortality giving the maximum yield per recruit in the long-term, F_{max}. Another important factor for classifying the status of a resource is the current stock level, e.g., spawning stock biomass (SSB). It is possible that a stock that is not currently overfished in terms of exploitation rates, is still at a low biomass level due to heavy exploitation in the past such that future recruitment to the stock is jeopardized. Therefore, the SAW Plenary, where possible, classified stocks as high, medium, or low biomass compared to historic levels.

Definitions of overfishing developed by the Fishery Management Councils can be related to exploitation rate (e.g., threshold percentage of the maximum spawning potential of the stock, %MSP) or biomass level (e.g., threshold spawning biomass) or a combination of the two. The SAW used these Council reference points in classifying stocks. The figure below describes the contingencies identified by SAW for this classification.

STOCK LEVEL

EXPLOITATION RATE

	LOW	MEDIUM	HIGH
OVER EXPLOITED	REDUCE EXPLOITATION REBUILD STOCK BIO MASS	REDUCE EXPLOITATION REBUILD STOCK STRUCTURE	REDUCE EXPLOITATION INCREASE YIELD PER RECRUIT
FULLY EXPLOITED	REDUCE EXPLOITATION REBUILD STOCK BIOMASS	MAINTAIN EXPLOITATION RATE AND YIELD	MAINTAIN EXPLOITATION RATE AND YIELD
UNDER EXPLOITED	MAINTAIN LOW EXPLOITATION WHILE STOCK REBUILDS	INCREASE EXPLOITATION SLOWLY TO REFERENCE LEVEL	INCREASE EXPLOITATION TO REFERENCE LEVEL

Summary graphs of the assessment results for each stock have been prepared to encapsulate the status of resources. These graphs include the basic information on historical patterns in the fisheries and current status. Included on each graph, where possible, is the definition of overfishing reference level from the relevant fishery management plan.

The SAW Plenary session also drew specific conclusions concerning stock status and, where possible, developed recommendations based on scientific advice. These conclusions were derived by consensus during the meeting.

Current levels of fishing are reported as instantaneous rates of fishing mortality (F) which are proportional to fishing effort and as annual exploitation rates (E), the proportion of vulnerable fish in the stock removed by the fishery each year. Many of the biological reference points used in definitions of overfishing are expressed as instantaneous fishing mortality rates (F) because of their simple relationship to fishing effort. However, exploitation rates are clearer and easier to appreciate for some readers because they are in terms of proportions (or percentages) of the available fish in the stock removed each year due to fishing. The reader is referred to the introduction of the annual NEFC **Status of the Fishery Resources Off the Northeastern United States** for more details concerning these parameters.

NORTHWEST ATLANTIC MACKEREL

An analytical assessment was conducted to estimate fishing mortality rates and stock sizes at age for this stock. Landings from all fisheries in 1990 are preliminarily estimated to be 49,512 MT. The U.S. commercial (including joint venture) fishery landings have been increasing and are currently 48% of the total but still are at a very low level compared to total historical landings (peaking at over 400,000 MT in 1973) and to the current estimated stock size.

Recent recreational landings are estimated to be one tenth of the U. S. commercial take. Total landings from all sources have been stable over the past decade.

Summary of Status

- Under-exploited, with respect to the definition of overfishing, and at a high stock level.
- Current F = 0.02 (2% exploitation rate); Reference $F_{0.1}$ = 0.27 (24% annual exploitation rate).
- $F_{0.1}$ catch is projected to be >400,000 in the short term (i.e. for the next 3 years).
- Spawning stock biomass has been increasing over the past decade and is currently at a record high. The best estimate for 1991 is 3 million MT.

Recommendations

- The fishery can sustain increased catches.
- Unless the fishery changes, given the current exploitation rate it is not necessary to conduct annual assessments. Enough information must, however, be available for setting quotas.

ATLANTIC MACKEREL

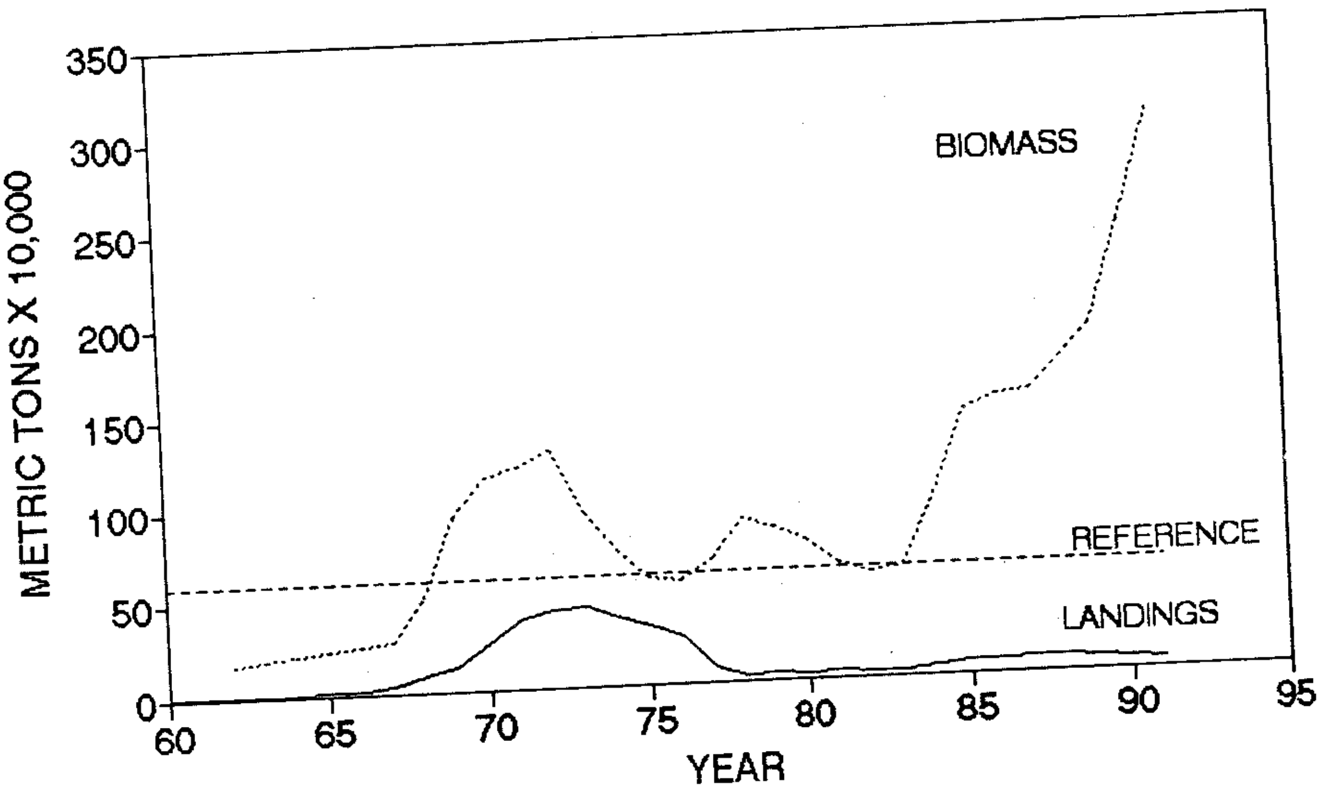

Figure AA1: Spawning stock biomass and landings of mackerel in tens of thousands of metric tons. The reference level indicates the biomass level corresponding to the definition of overfishing of the MAFMC.

ATLANTIC MACKEREL

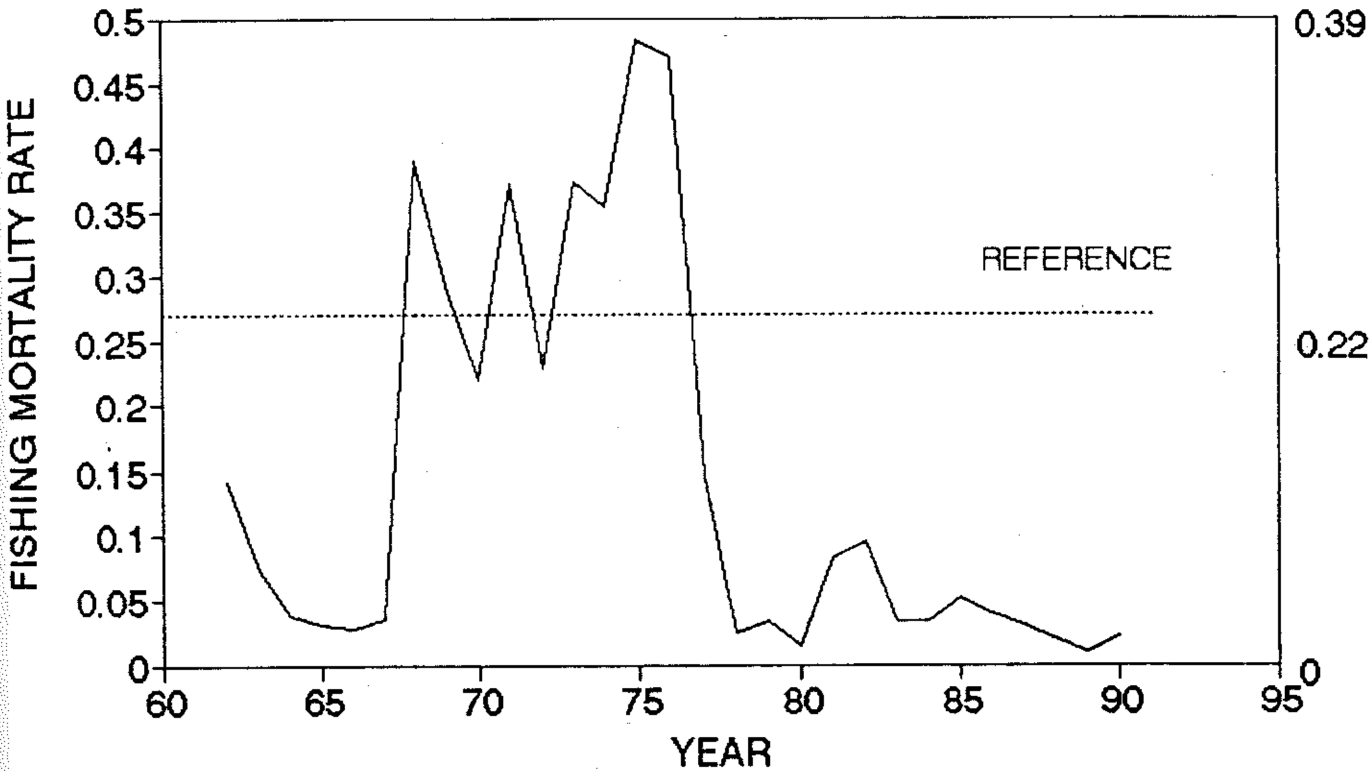

Figure AA2: Fishing mortality rate (left hand scale) and annual exploitation rate (right hand scale). The reference level indicates the F 0.1 level.

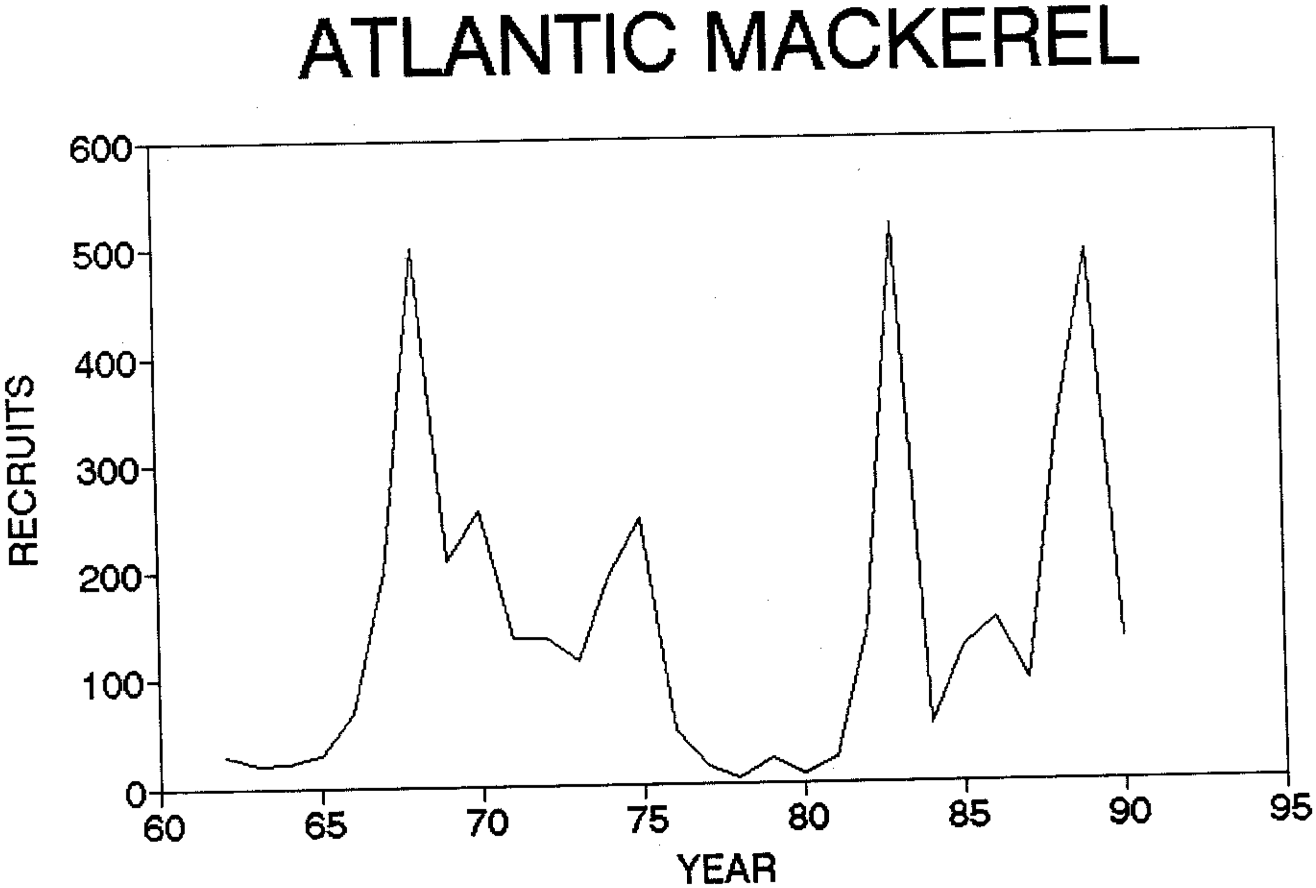

Figure AA3: Recruits at age one in tens of millions of fish.

ATLANTIC BUTTERFISH

This stock was evaluated based on trends in landings and survey indices of relative stock abundance. Current landings are about 3,000 MT, one quarter of the peak level in the 1970s.

Summary of Status

- Under-exploited, with respect to the definition of overfishing, and at a high stock level.
- Average landings in the late 1960s and early 1970s were 11,000 MT.
- Current landings are 3,000 MT, not including foreign fishing.
- Recent survey pre-recruit indices have been high relative to historical levels.

Recommendations

- Current stock can support a catch level of 16,000 MT for the next 2 years.
- Unless the rate of exploitation increases, annual assessments are not necessary.

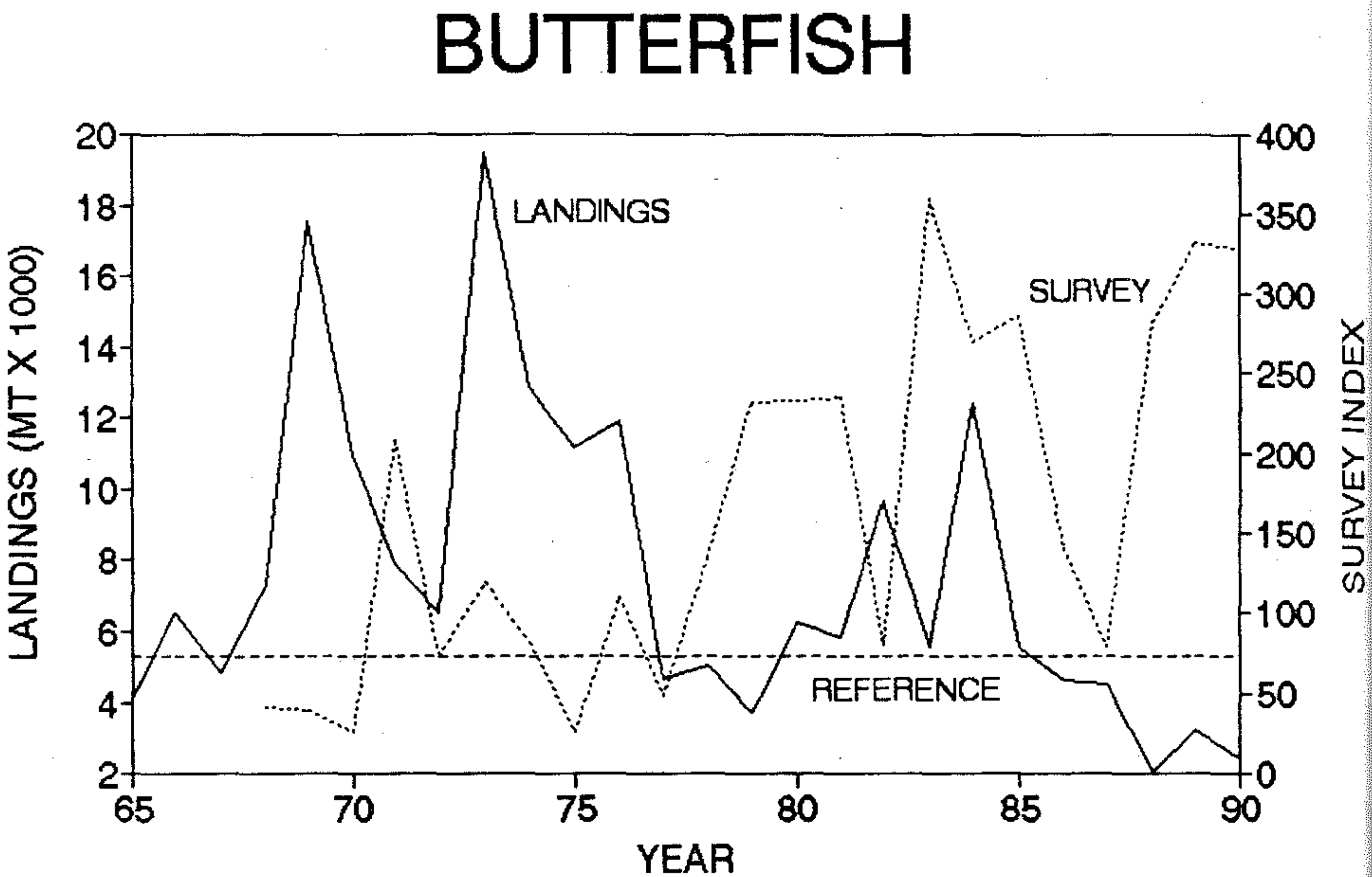

Figure AB1: Butterfish landings in thousands of metric tons and pre-recruit survey index in numbers per tow. The reference line corresponds to the MAFMC definition of the overfishing threshold with respect to the survey for this stock.

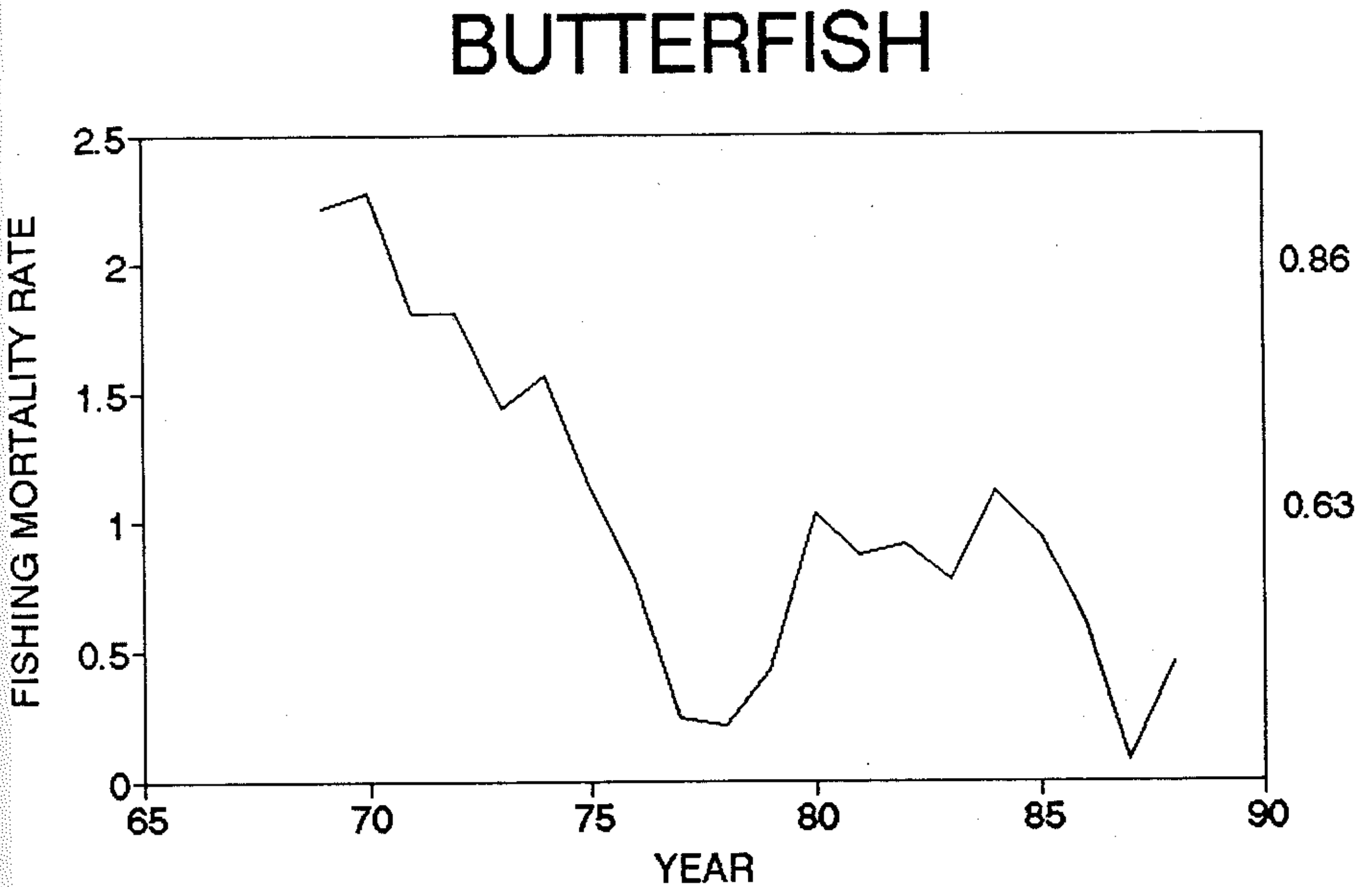

Figure AB2: Estimated fishing mortality rate (left scale) and annual exploitation rate (right scale) from survey indices. The estimates were smoothed with a three year moving average.

GULF OF MAINE COD

An analytical assessment was conducted to estimate fishing mortality rates and stock abundance at age and biological reference points for this stock. Current commercial fishery landings are 15,100 MT, increasing over the past two years in response to recruitment of a large 1987 year class.

Summary of Status

- Over-exploited, with respect to the definition of overfishing, and at a medium stock level.
- Recent year classes are at or below average. The spawning stock is largely made up of two year classes.
- The 1990 F = 0.90 (59% annual exploitation rate); reference point at 20% MSP is $F_{20\%}$ = 0.40 (33% annual exploitation rate).
- The current fishing mortality rate is more than 2 times the definition of overfishing level.
- If F remains at the 1990 level, projected catch for 1992 is 13,700 MT; the projected catch with $F_{20\%}$ is 7,200 MT.
- In 1990, the SSB was at the highest level in a decade. SSB under constant F at the 1990 level decreases 18%; with $F_{20\%}$, SSB increases 11% by 1992 - 1993.
- As discards are not included, technical aspects of the assessment suggest that the estimated fishing mortality rates may be under-estimates and the estimated stock sizes over-estimates of current levels.

Recommendations

- Fishing mortality rates need to be reduced to rebuild stock and widen the number of age groups in the spawning stock biomass.
- Reducing the rate of fishing mortality to the reference level (20% MSP) which defines overfishing would result in a 24% increase in yield per recruit and a 100% increase in spawning biomass per recruit.
- Reconcile minimum fish size and mesh size regulations to reduce discards.

GULF OF MAINE COD

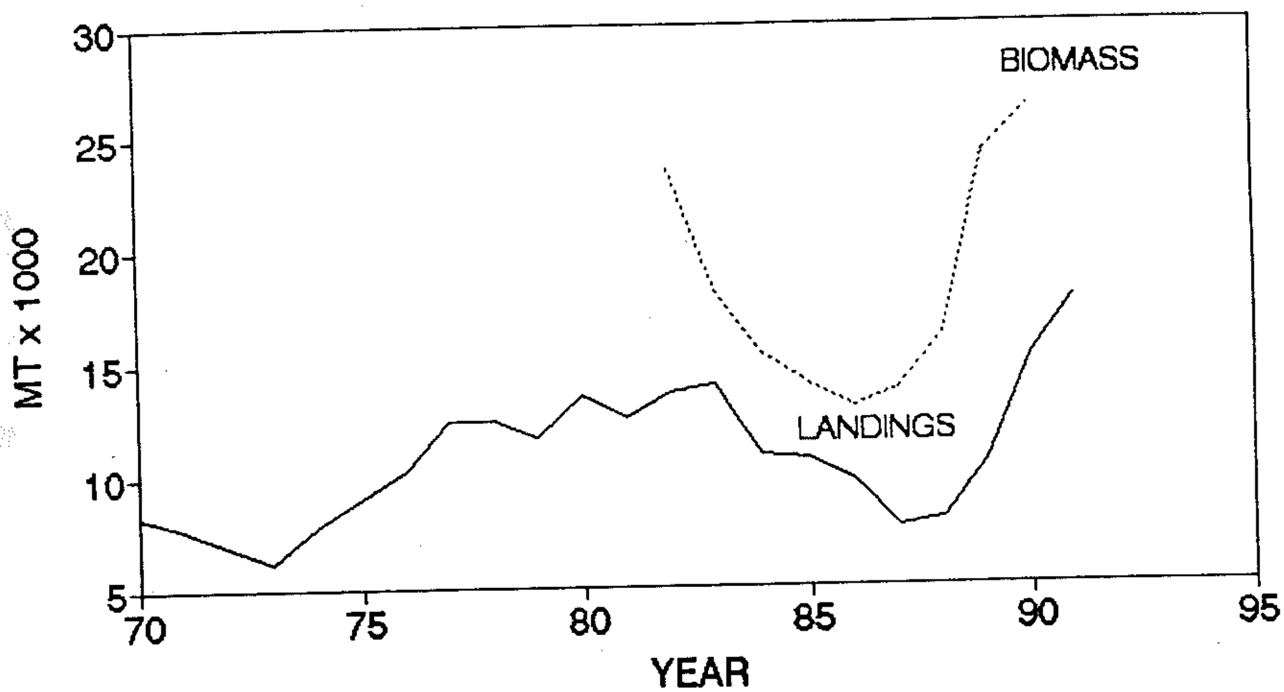

Figure AC1: Biomass and landings of Gulf of Maine cod in thousands of MT.

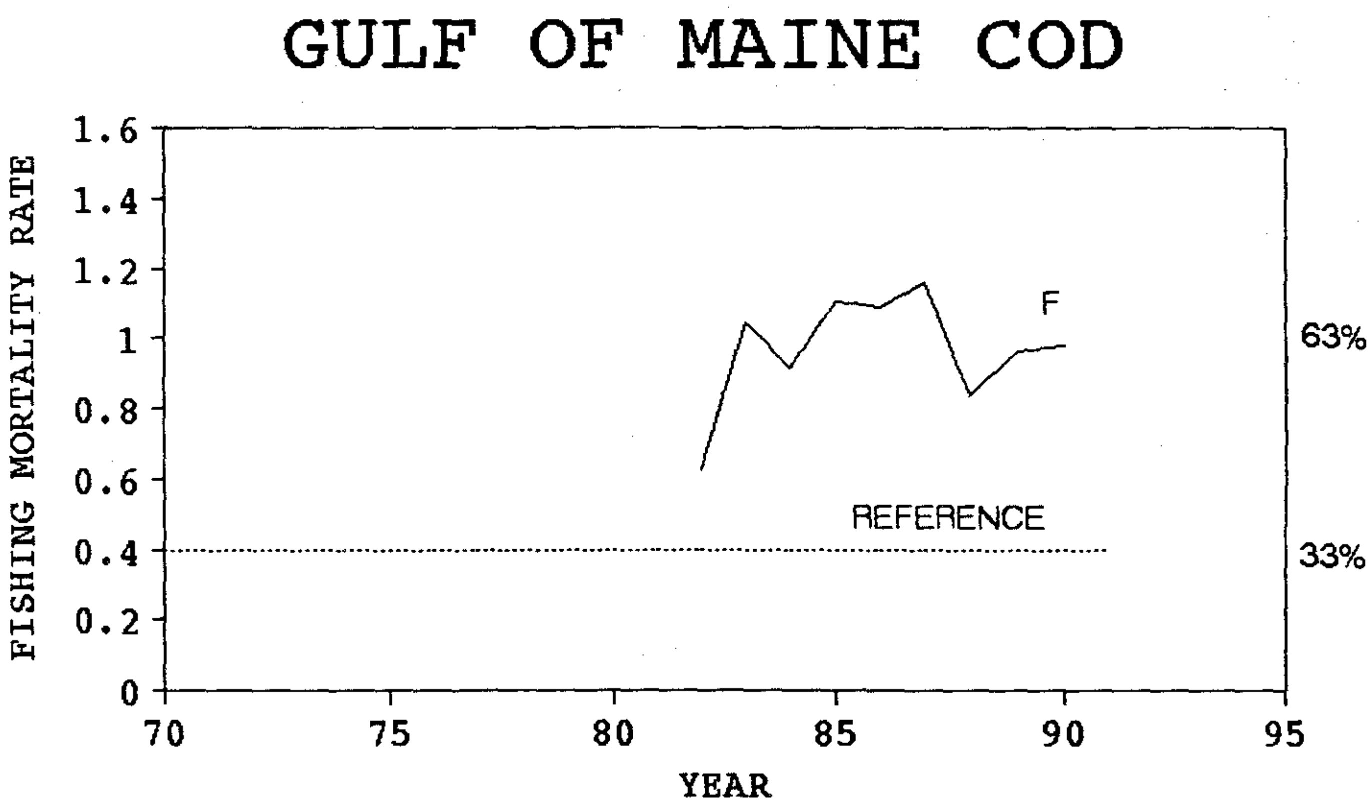

Figure AC2: Fishing mortality rate (left hand scale) and annual exploitation rate (right hand scale) for cod. The reference line corresponds to the NEFMC definition of overfishing.

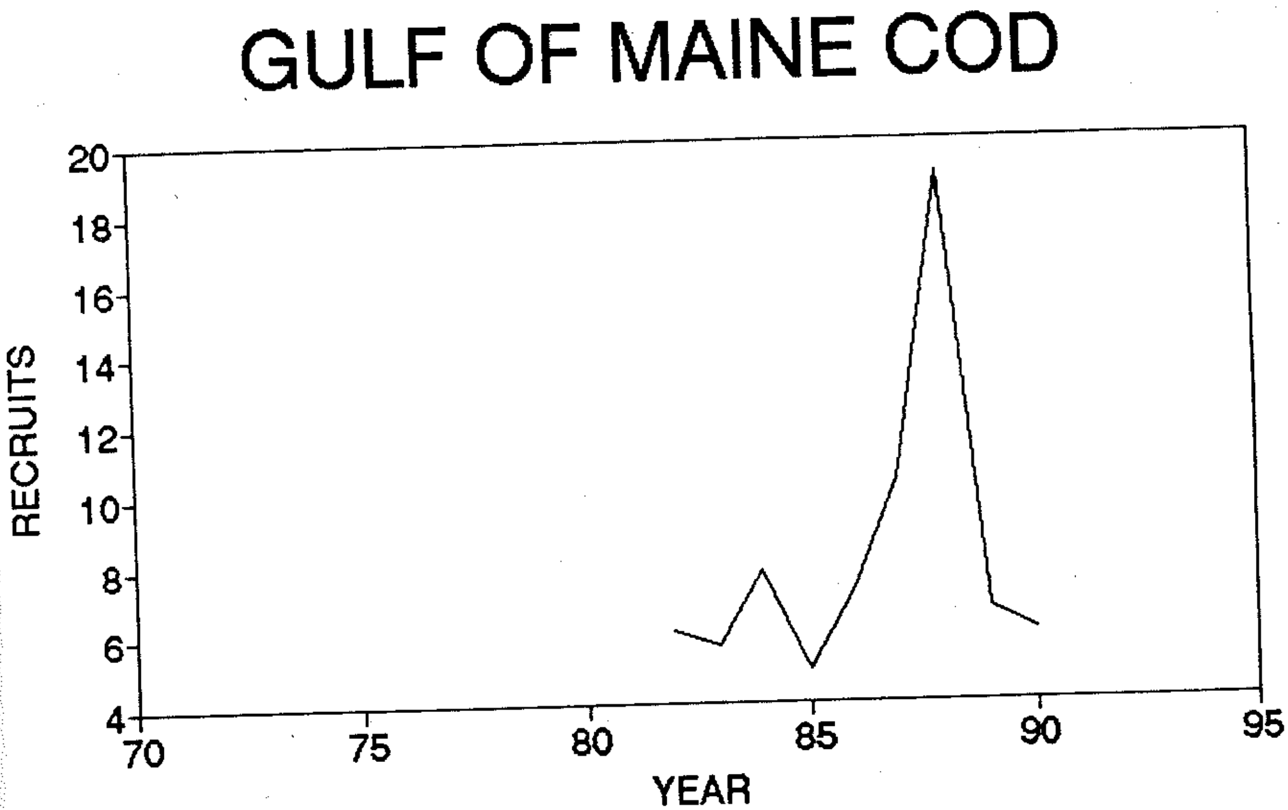

Figure AC3: Recruitment of cod in milions of fish at age 1.

YELLOWTAIL FLOUNDER

Analytical assessments of the Southern New England (SNE) and Georges Bank (GB) stocks of yellowtail flounder were conducted to estimate fishing mortality rates, discard proportions, and stock sizes at age.

Recent landings have been 8000 MT from Southern New England and 2700 MT from Georges Bank, an increase over the previous five years largely resulting from increased effort and the recruitment of large 1987 year classes to both stocks.

Discard rates for the large 1987 year classes were very high as a result of high fishing effort on the grounds and minimum size regulation. These cohorts have been considerably fished down now and there is no indication of subsequent year classes which will substantially rebuild the stocks.

Summary of Status

- Both stocks are over-exploited, with respect to the definition of overfishing, and at low stock abundance levels.

- The 1990 fishing mortality rate in SNE is 1.6 (annual exploitation rate 80%) compared to the reference rate $F_{20\%}$of 0.49 (annual exploitation rate 60%).

- The 1990 fishing mortality rate in GB is 0.82 (annual exploitation rate 56%) compared to the reference level $F_{20\%}$of 0.58 (annual exploitation rate 44%).

- Prior to 1989 the spawning biomass (SSB) of both stocks was low. Although the 1987 year-class rebuilt the SSB to a high level, high fishing mortality on age 2 rapidly reduced the SSB. The stock is expected to be near a record low level in 1991.

- If current F is maintained, the SSB is expected to continue to fall. If F is reduced to the reference level, there should be some increase by 1993.

- Discards of age 3 fish in 1990 were at an unprecedented level (51%) in both areas due to the combination of the minimum size regulation and predominant mesh size in use. Large amounts of future yield were foregone.

- The fishery is strongly dependent on the recruiting year-class. As there are very few age classes in the fishery, the risk is high for a sharp reduction in landings due to poor recruitment in any one year.

Recommendations

- Reduce the overall fishing mortality to stabilize landings and increase SSB/R. Reducing F to the reference level is estimated to give a 9 fold increase in spawning biomass per recruit in Southern New England and a 40% increase for the Georges Bank stock.

- Reducing fishing mortality only on younger ages (e.g., adjusting mesh size) is insufficient to reduce the overall fishing mortality to levels necessary to rebuild the stock and stabilize landings. As big year-classes attract effort and undermine management, direct controls are required.

- Reconcile minimum fish size and mesh size to reduce discarding and foregone yield.

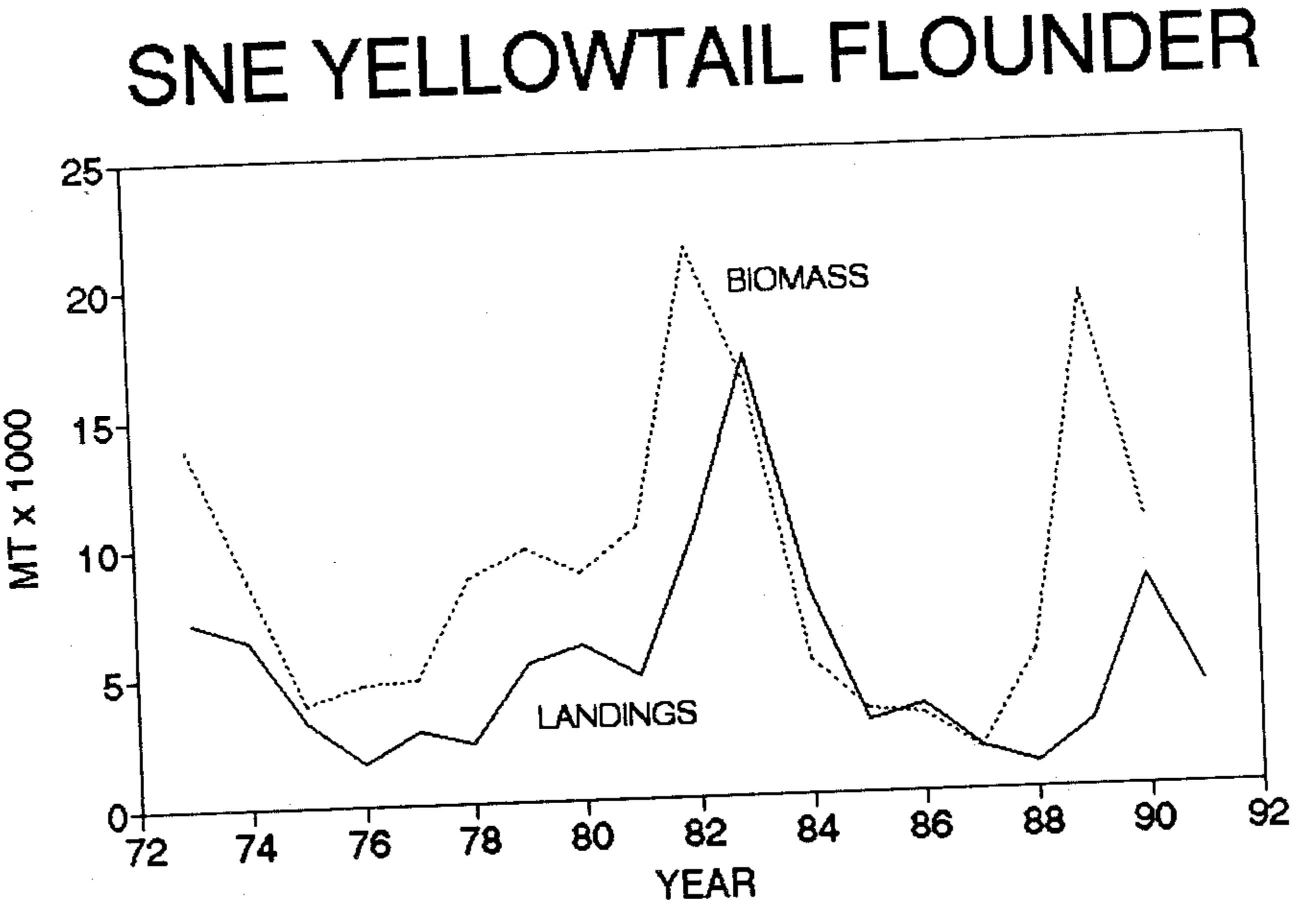

Figure AD1: Spawning stock biomass and landed catch in weight of southern New England yellowtail flounder.

SNE YELLOWTAIL FLOUNDER

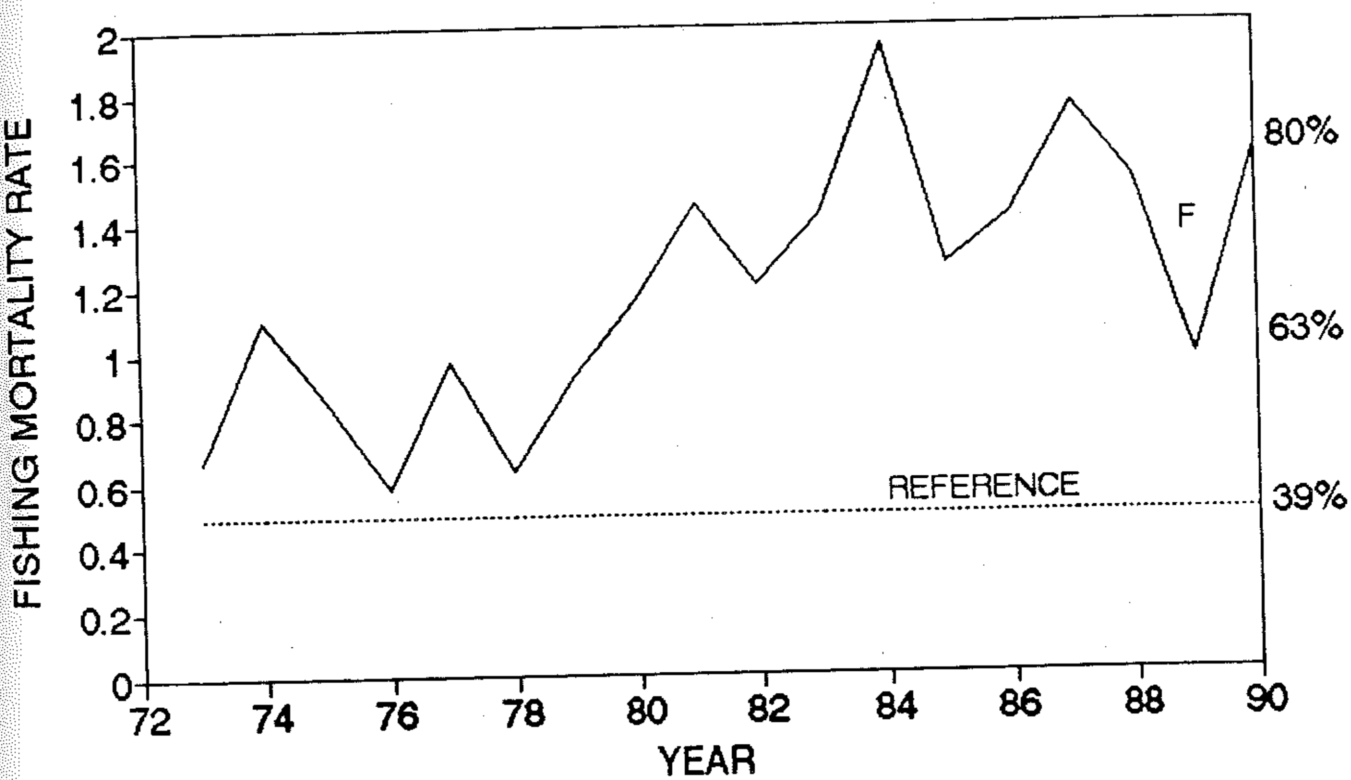

Figure AD2.: Fishing mortality rate (left scale) and annual exploitation rate (right scale) for SNE yellowtail flounder. The reference line is the overfishing definition of the NEFMC.

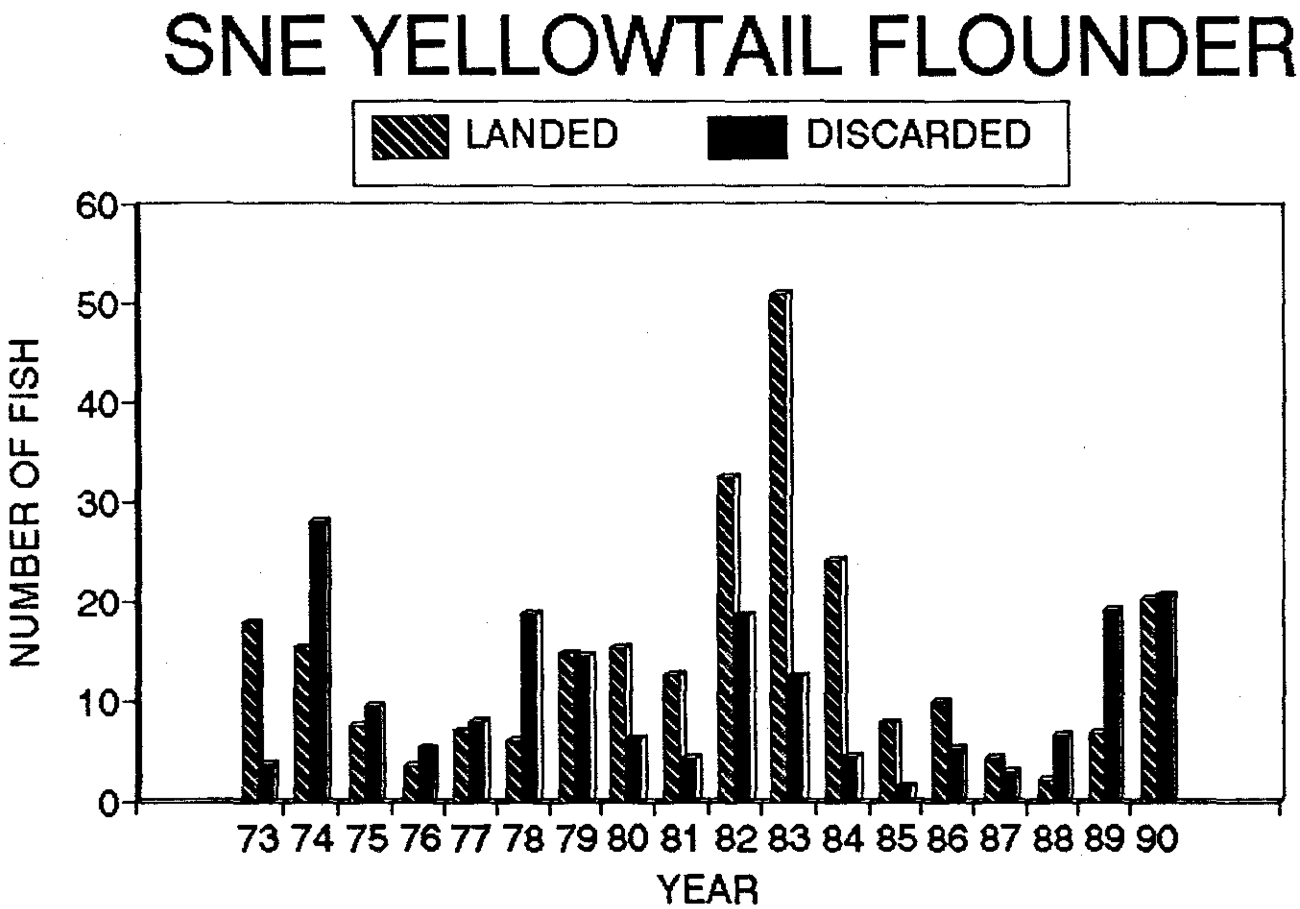

Figure AD3: Number of fish in millions landed and discarded in the SNE yellowtail flounder fishery.

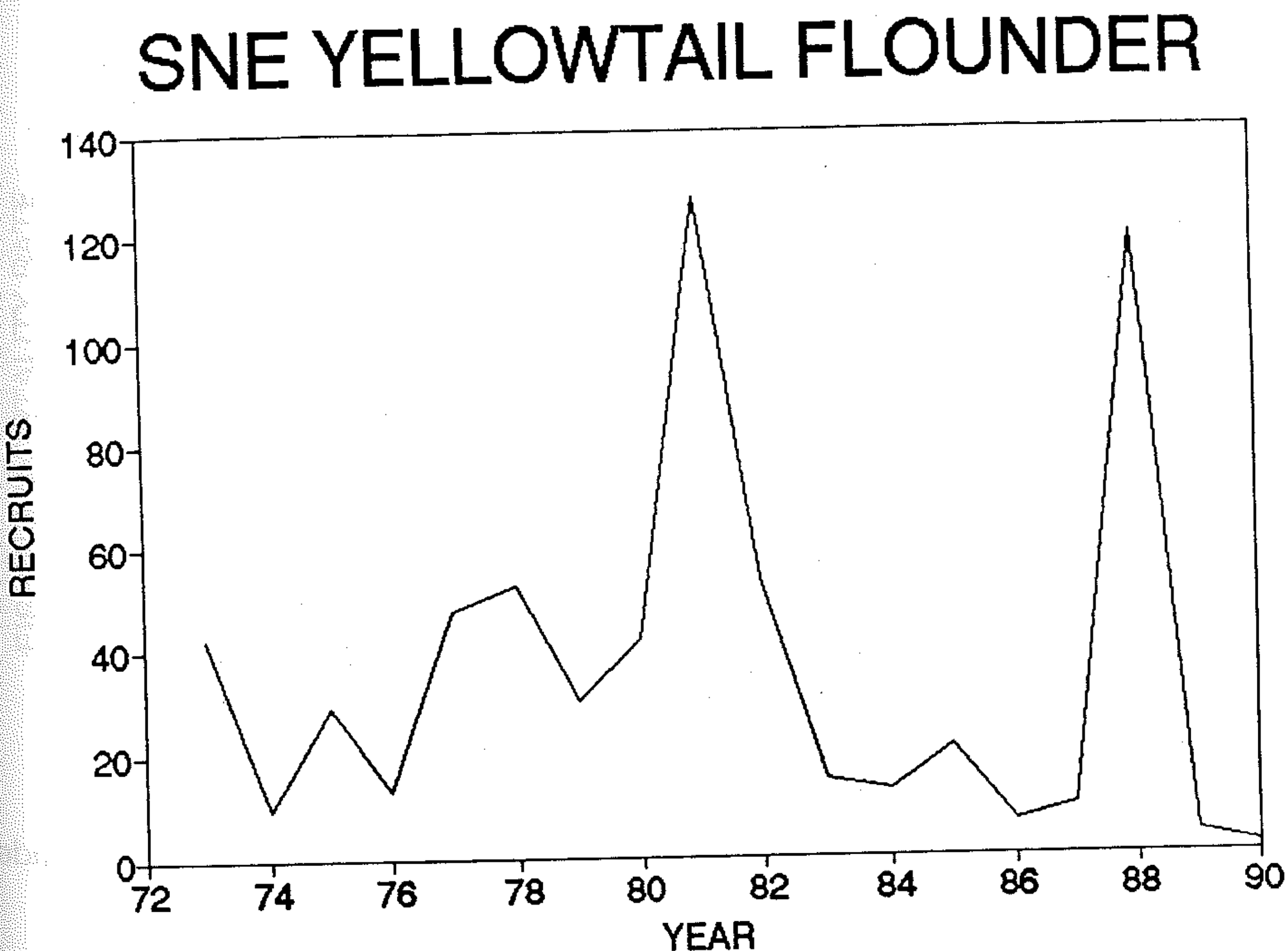

Figure AD4: Recruitment in millions of fish.

GB YELLOWTAIL FLOUNDER

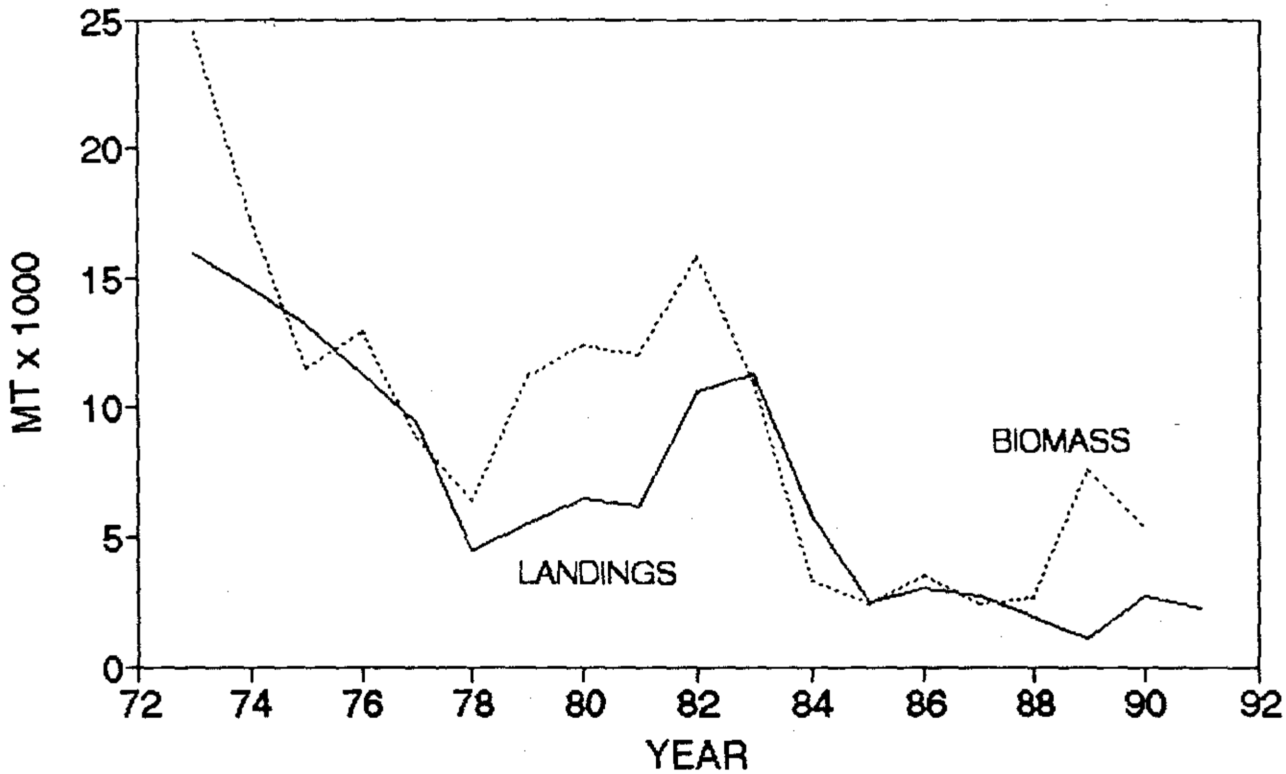

Figure AD5: Landings and spawning biomass for George s Bank yellowtail flounder.

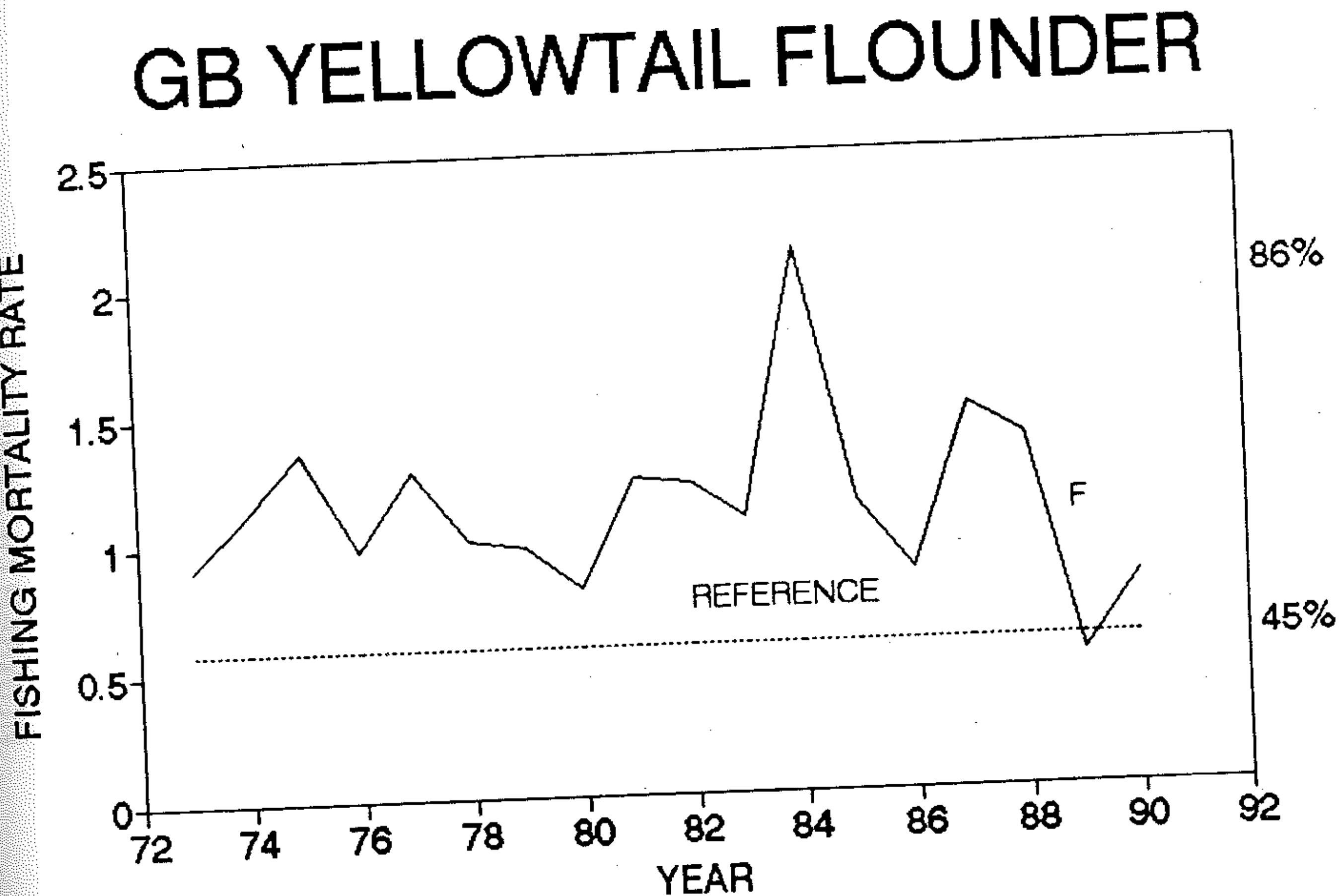

Figure AD6: Fishing mortality rate (left scale) and annual exploitation rate for George s Bank Yellowtail flounder.

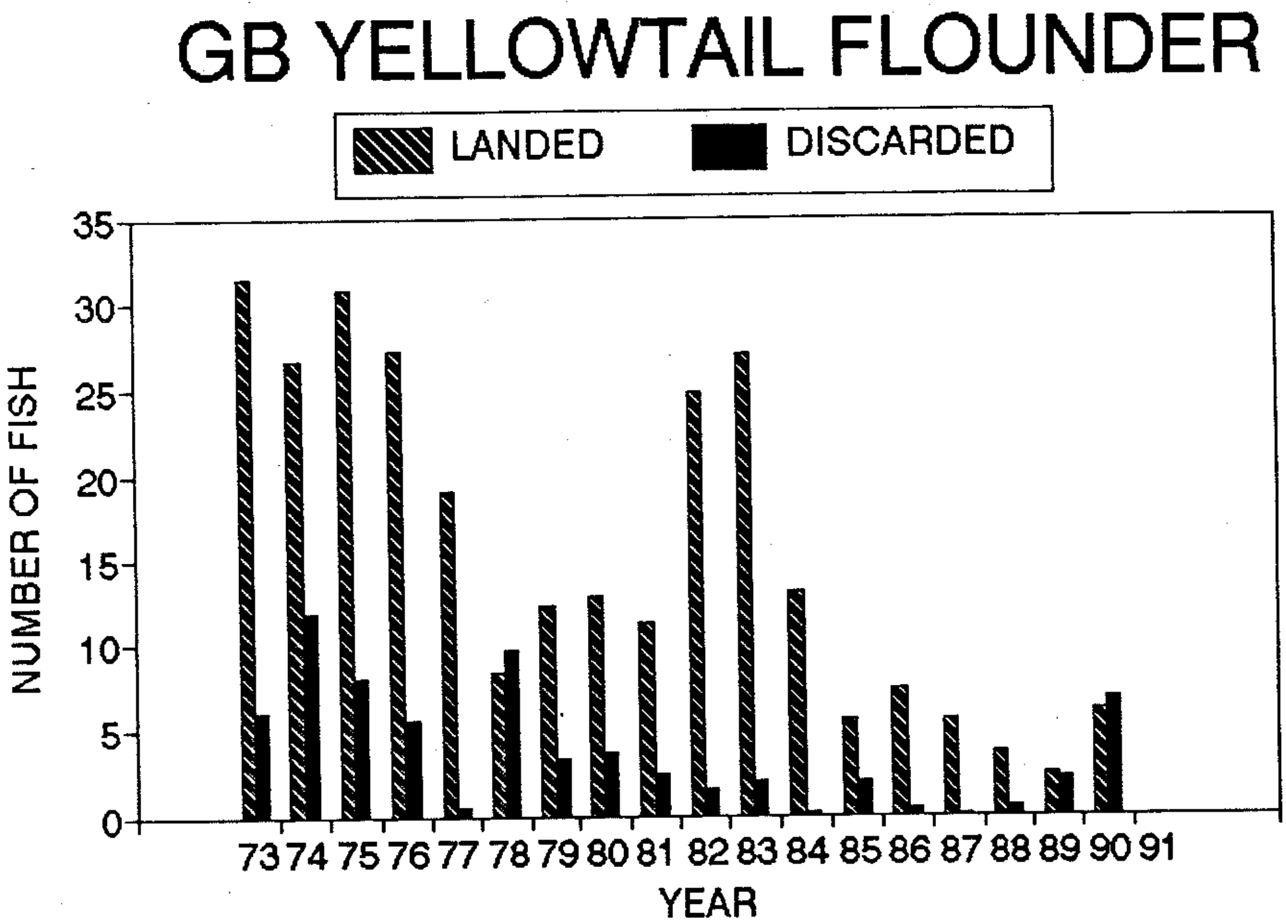

Figure AD7: Discards and landed numbers of fish in millions for George s Bank yellowtail flounder.

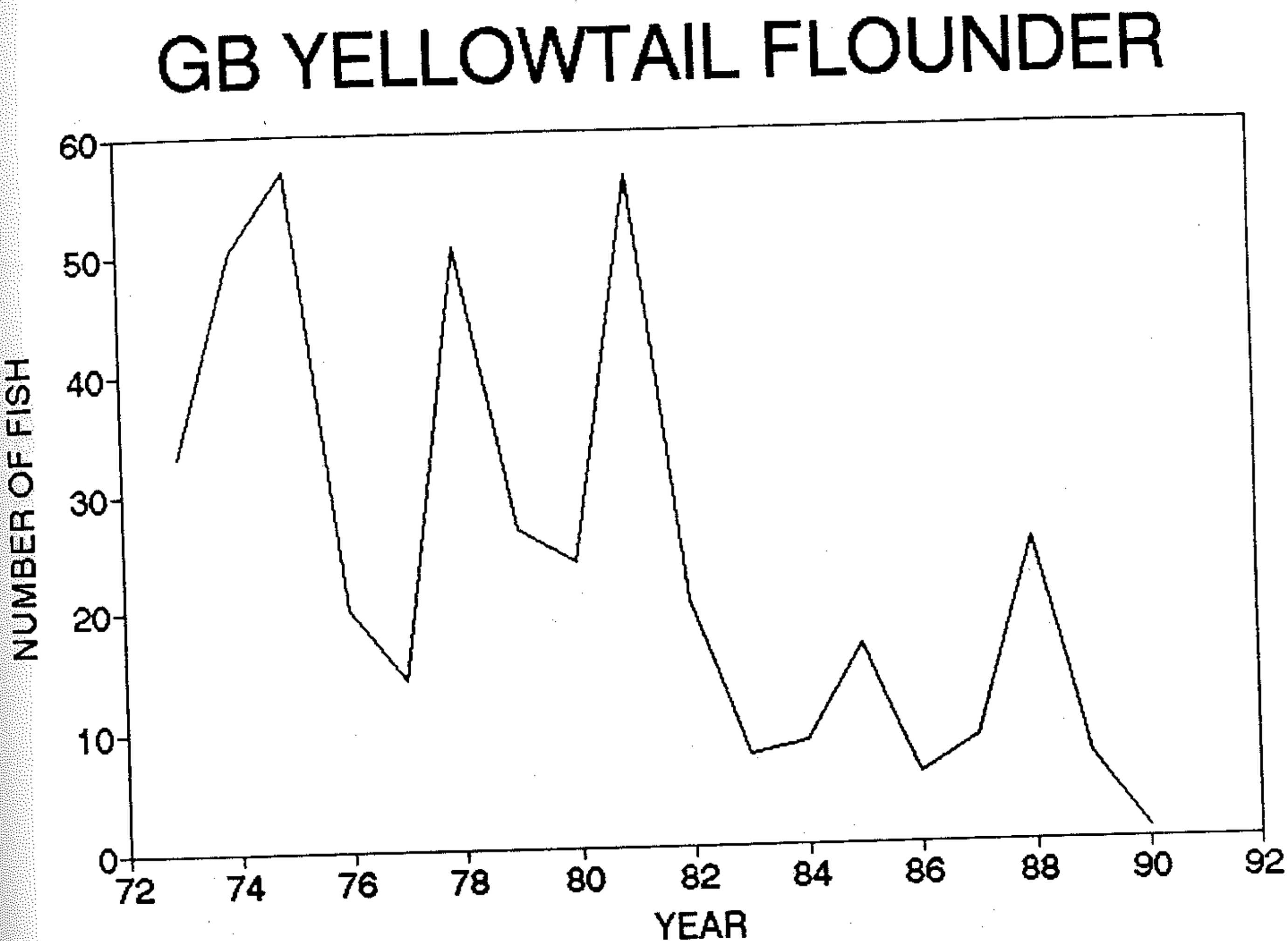

Figure AD8: Recruitment in millions of fish for George s Bank yellowtail flounder.

SHORT FIN SQUID

Indices of abundance and landings data were analyzed. Current landings have increased in recent years to 11,000 MT. Directed effort has increased substantially while catch per unit of effort has dropped.

Summary of Status

- Under-exploited, with respect to the definition of overfishing, and at medium stock level.
- Domestic landings have increased over 1989 (66%) and over the 1982 - 1989 average (55%) to around 11,000 MT in 1990.
- The 1990 overall survey index is above average (74%), while the 1990 pre-recruit index is around the average for the period of 1967 - 1989.
- While total effort increased strongly in 1990, catch per unit of effort decreased on average for the fleet. This decrease probably resulted from fishing down of local concentrations as well as the relative inefficiency of vessels new to the fishery, rather than a decline of total stock abundance.
- Sub-stock and cohort structure complicate the interpretation of abundance indices and need further investigation.
- The fishery and the survey do not cover the full range of the Illex stock. Therefore, landings and survey indices will vary due to changes in resource distribution and may not reflect actual changes in population abundance.

Recommendations

- Careful monitoring of this fishery, which is undergoing rapid changes, is needed.
- Alternative reference points and indices may be needed.

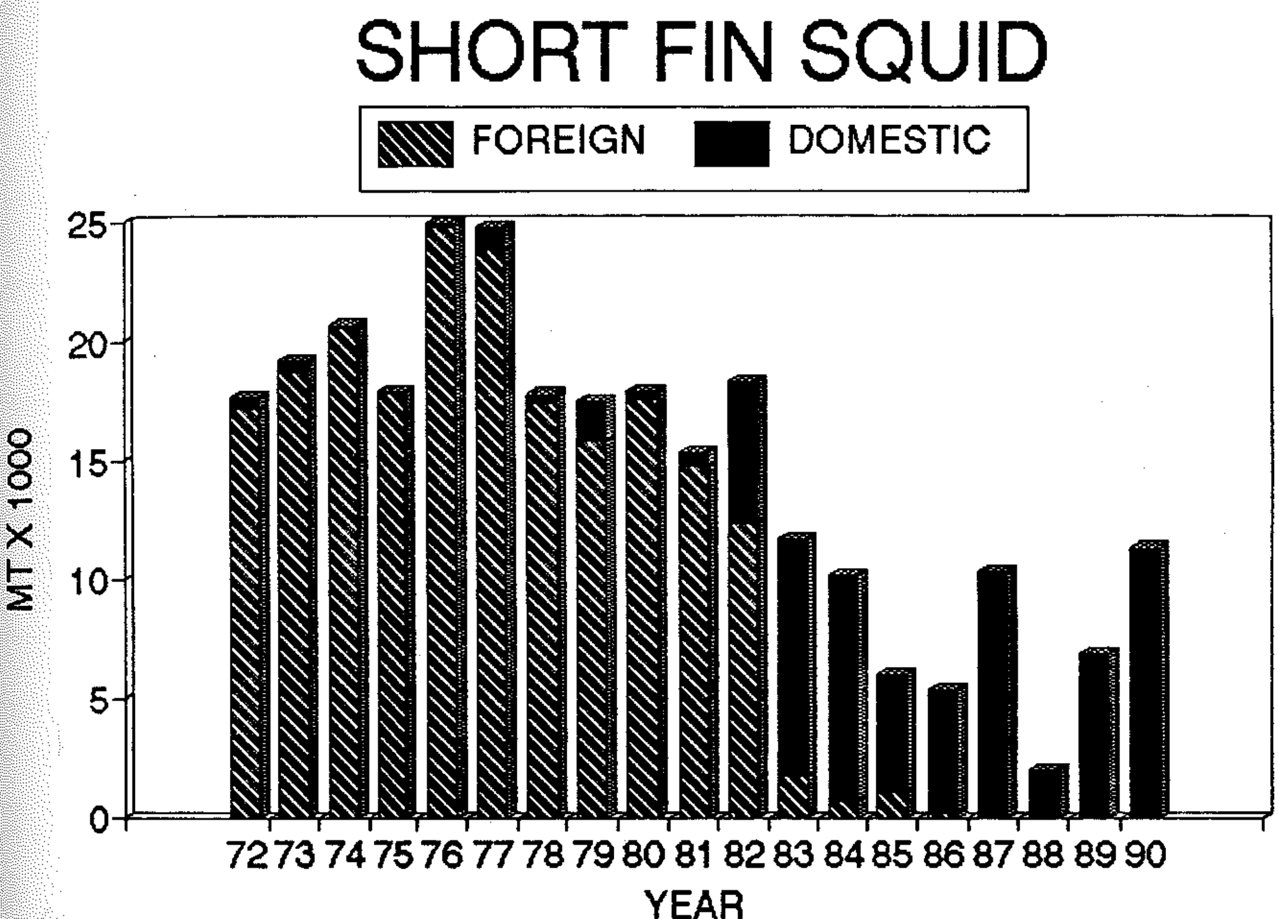

Figure AE1: Foreign and domestic landiings of Illex squid.

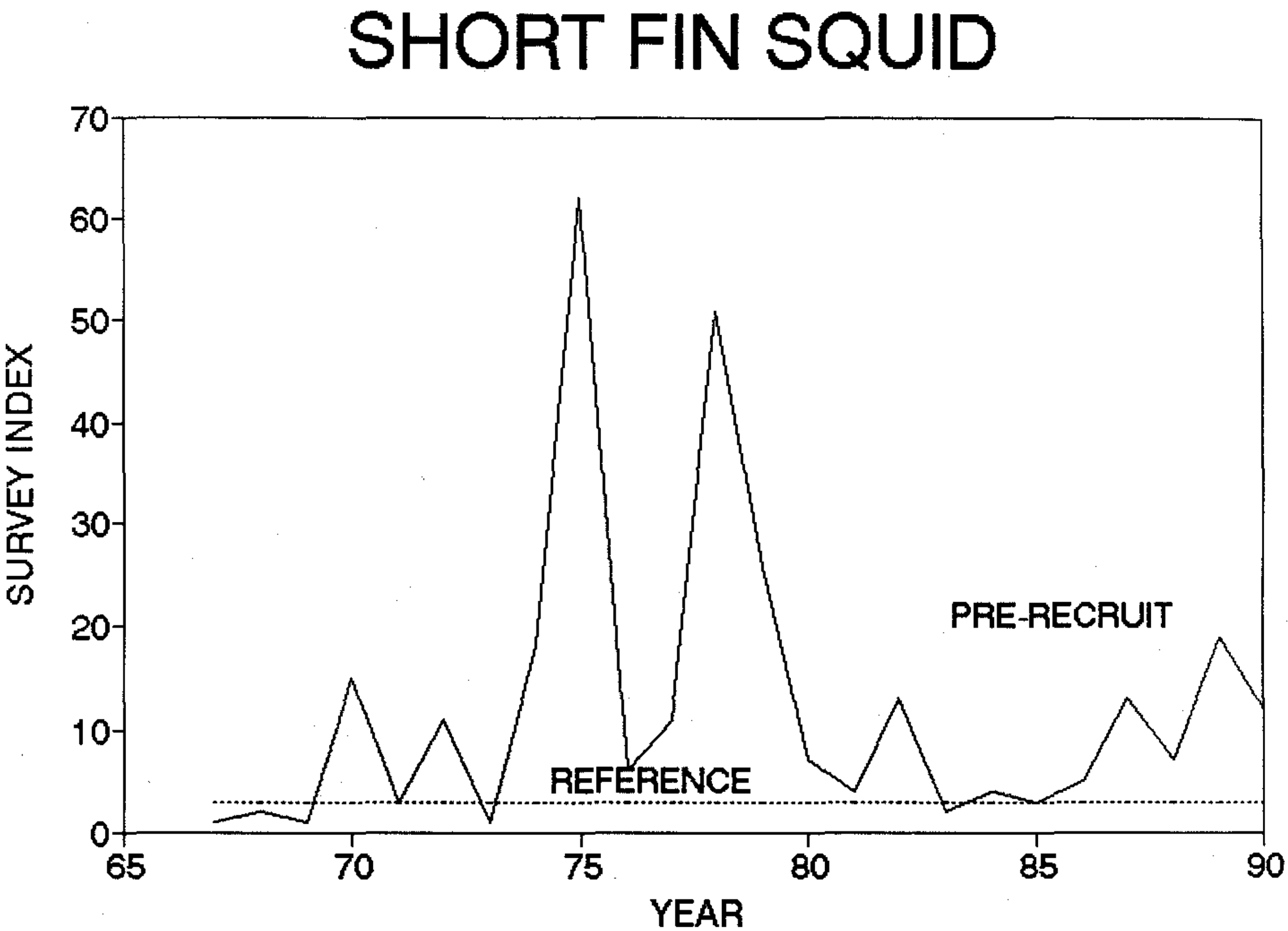

Figure AE2: Pre-recruit survey index (numbers per tow X 10) and the MAFMC overfishing definition for Illex squid.

LONG FIN SQUID

Indices of abundance and landings data were analyzed. Some new forecasting tools were applied to this stock in the new assessment.

Current landings are around 15,000 MT entirely taken by the domestic fleet. Catch per unit of effort decreased in 1990 and the effort decreased as well following two years of higher effort and catch rates.

Summary of Status

- Under-exploited, with respect to the definition of overfishing, and at a medium stock level.

- Since 1983, the domestic fishery has been 10 - 20,000 MT. In 1990, the fishery was about 15,000 MT, a decrease of 33% from 1989.

- Current survey indices are high compared to the 1967 - 1990 average. Although the abundance decreased from 1988 - 1989, there is an overall upward trend in abundance.

- Commercial Catch Per Unit Effort (CPUE) decreased by 41% in 1990 along with the effort as compared to 1988 - 1989.

- The 1991 forecast recruitment index continues to decrease from the 1989 peak. This recruitment is related to fishery performance, which is also expected to decline in 1991 from the high 1989 levels.

Recommendations

- It is recommended to monitor the stock closely, as major changes in the fishery occurred in the last few years that impact on the landings and CPUE. There is a high potential to expand this fishery rapidly making the stock vulnerable to over-exploitation.

- Alternative indices and reference points are required for monitoring.

- Sub-stock and cohort structure complicate the interpretation of abundance indices and need further investigation.

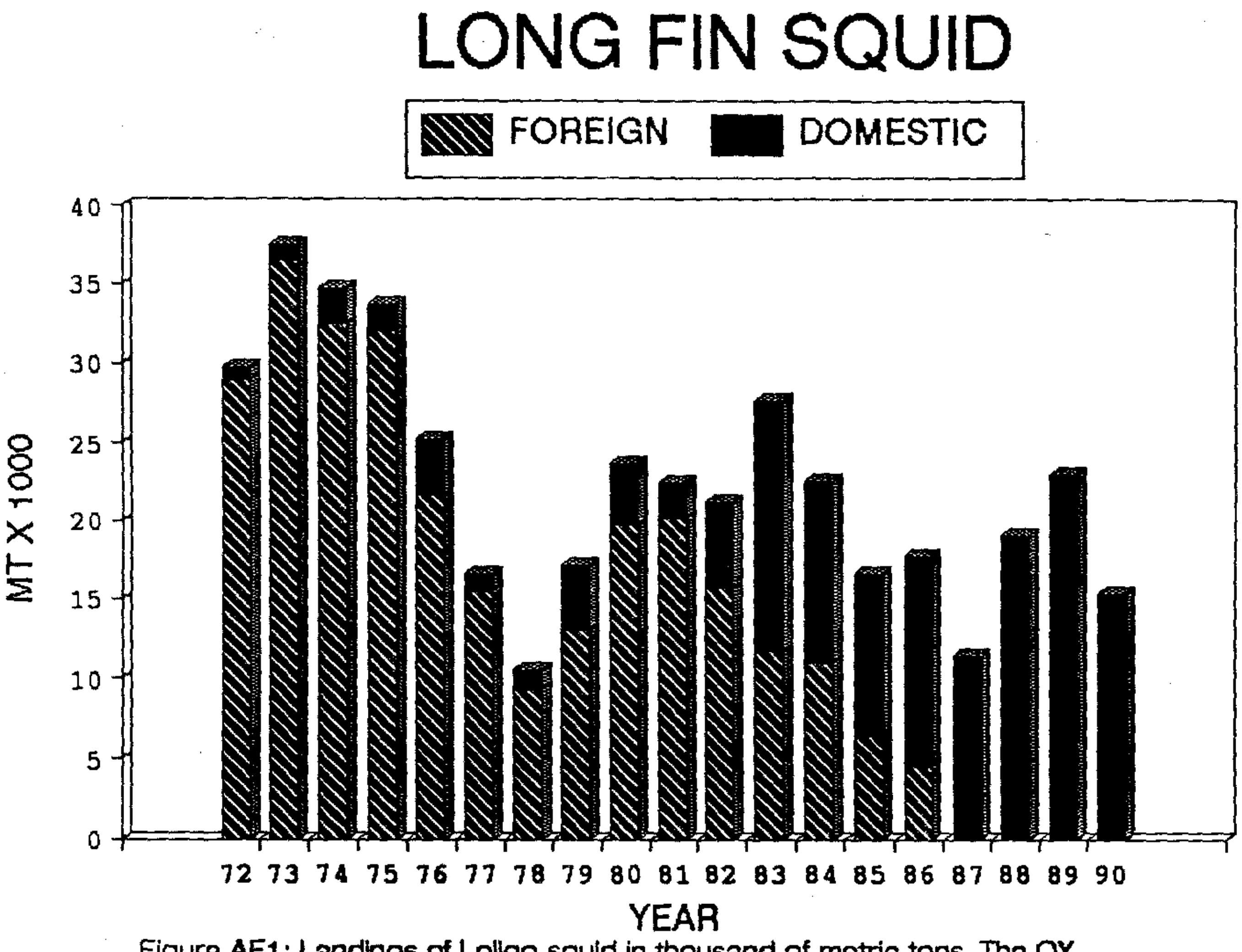

Figure AF1: Landings of Loligo squid in thousand of metric tons. The OY for this stock specified by the MAFMC is 44,000 MT.

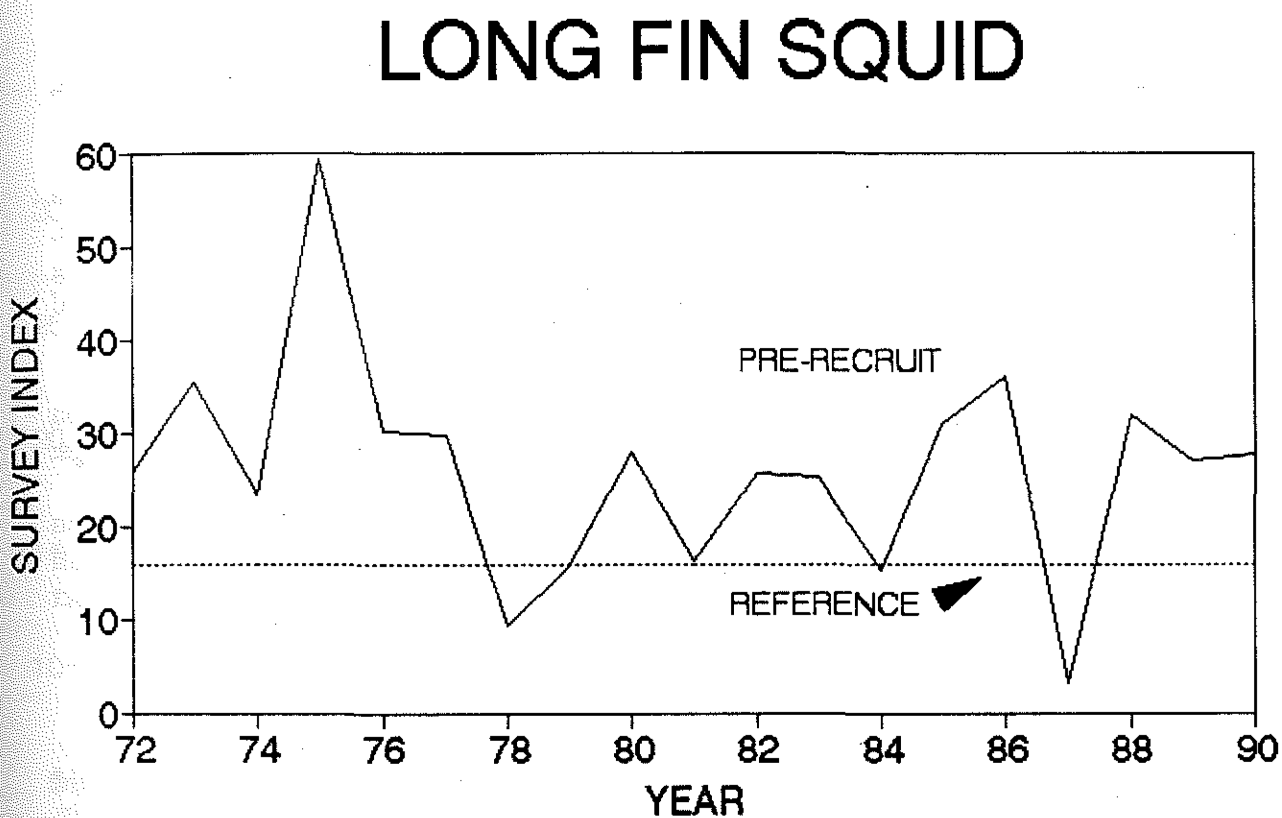

Figure AF2: Pre-recruit squid survey index in (numbers per tow)/10.
The reference line corresponds to the definition of overfishing of the MAFMC.

ATLANTIC SEA SCALLOPS

Analytical assessments of sea scallops in the Delmarva and South Channel regions estimated fishing mortality rates and stock sizes of pre-recruits and recruited animals. The two areas analyzed reflect the nature of the fishery in other major areas as well. The U.S. landings in 1990 were estimated to be about 17,000 MT from all areas. The landings have been increasing over the past five years and 1990 was a record high.

Summary of Status

- o Over-exploited, with respect to the available reference points for scallops, and at a medium stock size.

- o Current fishing mortality on fully recruited scallops in both areas was in excess of 2.0 (E = 86%) in 1987, and have been at very high levels for a decade. There is no reference point for scallops in the FMP; however, current fishing mortality rates are ten times the level estimated to give the maximum yield per recruit.

- o There are few year-classes in the stock. The fishery depends each year on new recruitment and is therefore at high risk of a sharp decline in landings.

- o Pre-recruit survey indices are at or near record levels in 1990 - 1991. Given the increases in fishing effort and abundance indices, landings in 1991 will likely increase over 1990, contingent on management measures which effect the size of scallops landed and/or the total amount of fishing effort.

Recommendations

- o Reducing the current level of fishing mortality by 50% would increase yield per recruit by 20%. Decreasing F by 75% is expected to result in a 40% increase in yield per recruit.

- o Take advantage of the excellent opportunity to rebuild the stock's age structure and spawning biomass without lengthy reductions in yield because of recent good recruitment

- o Reduce F to stabilize landings and extend the yield of cohorts over several years.

- o Sampling/aging of commercial size composition would improve assessments of fishery performance.

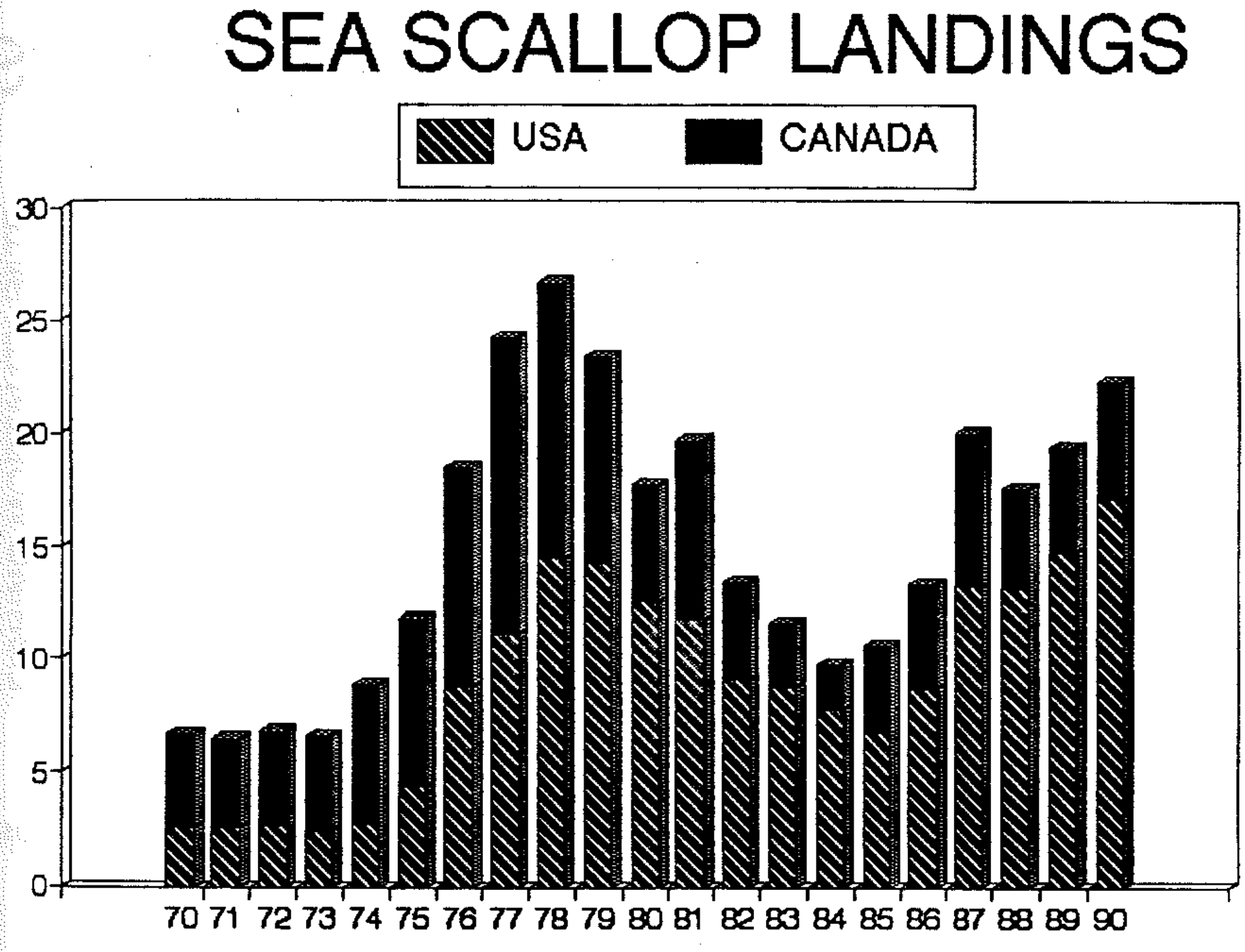

Figure AG1: Overall scallop landings from the Northwest Atlantic.

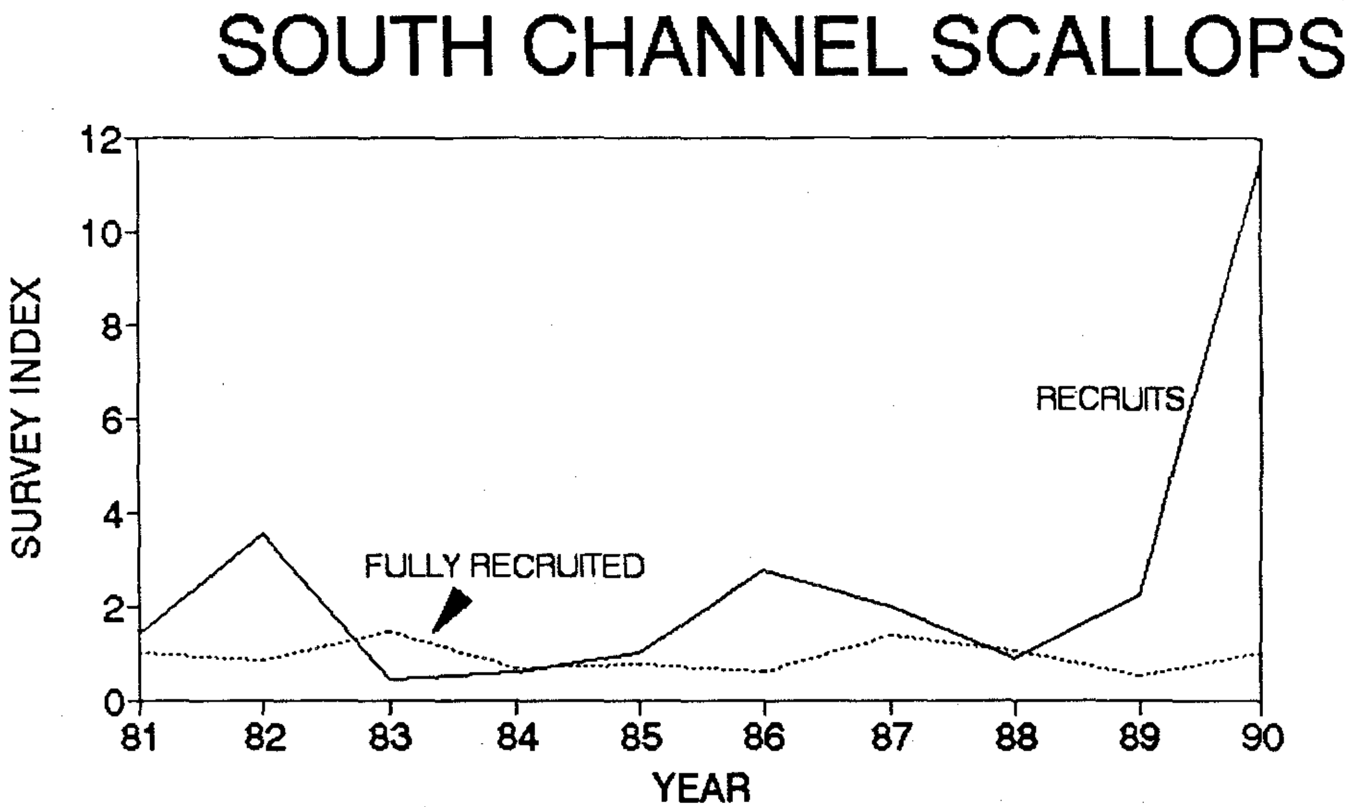

Figure AG2: Survey indices of partiially recruited (recruits) and fully recruited scallops in the South Channel area. Indices are numbers per tow.

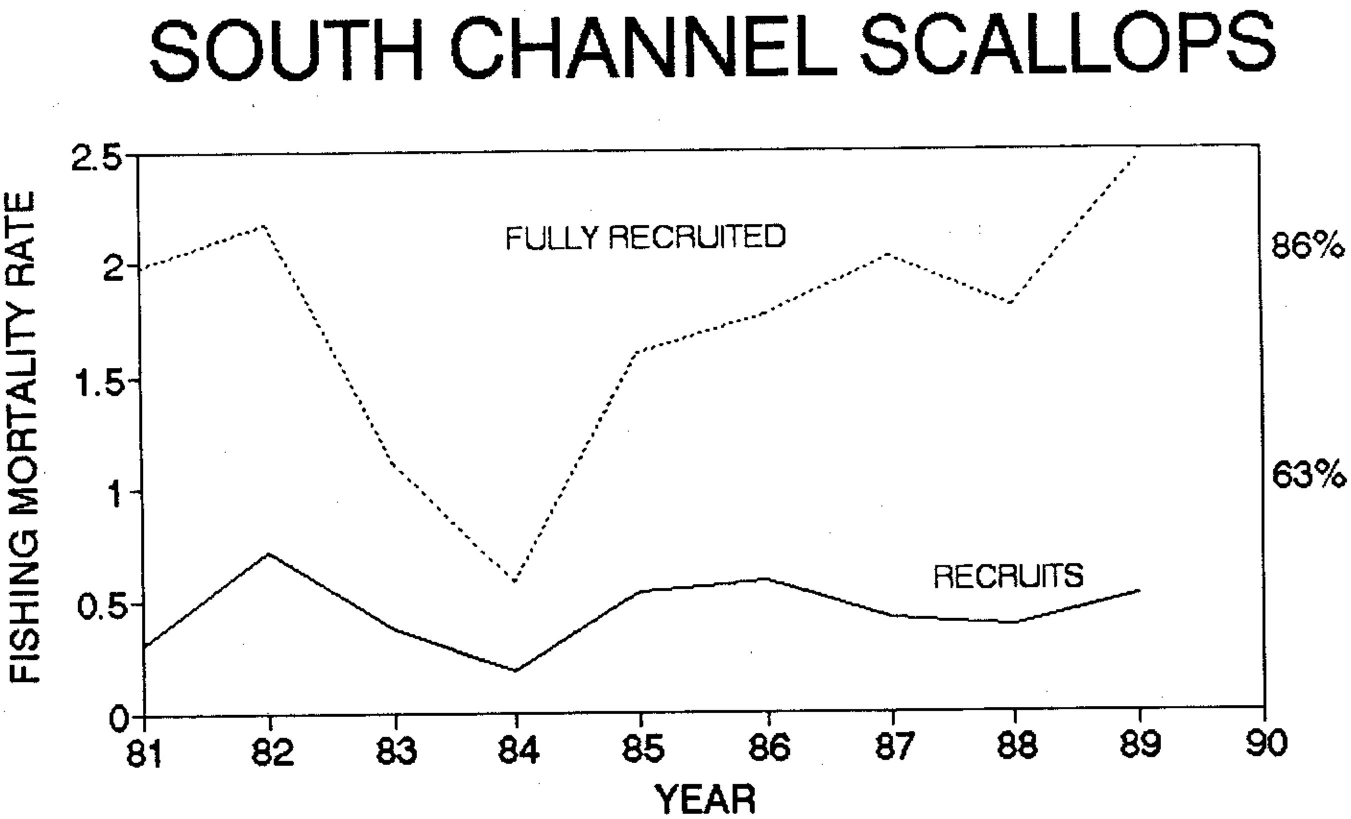

Figure AG3: Fishing mortality rates (left scale) and annual exploitation rates (right scale) for partiially recruited (recruits) and fully recruited scallops in the South Channel area.

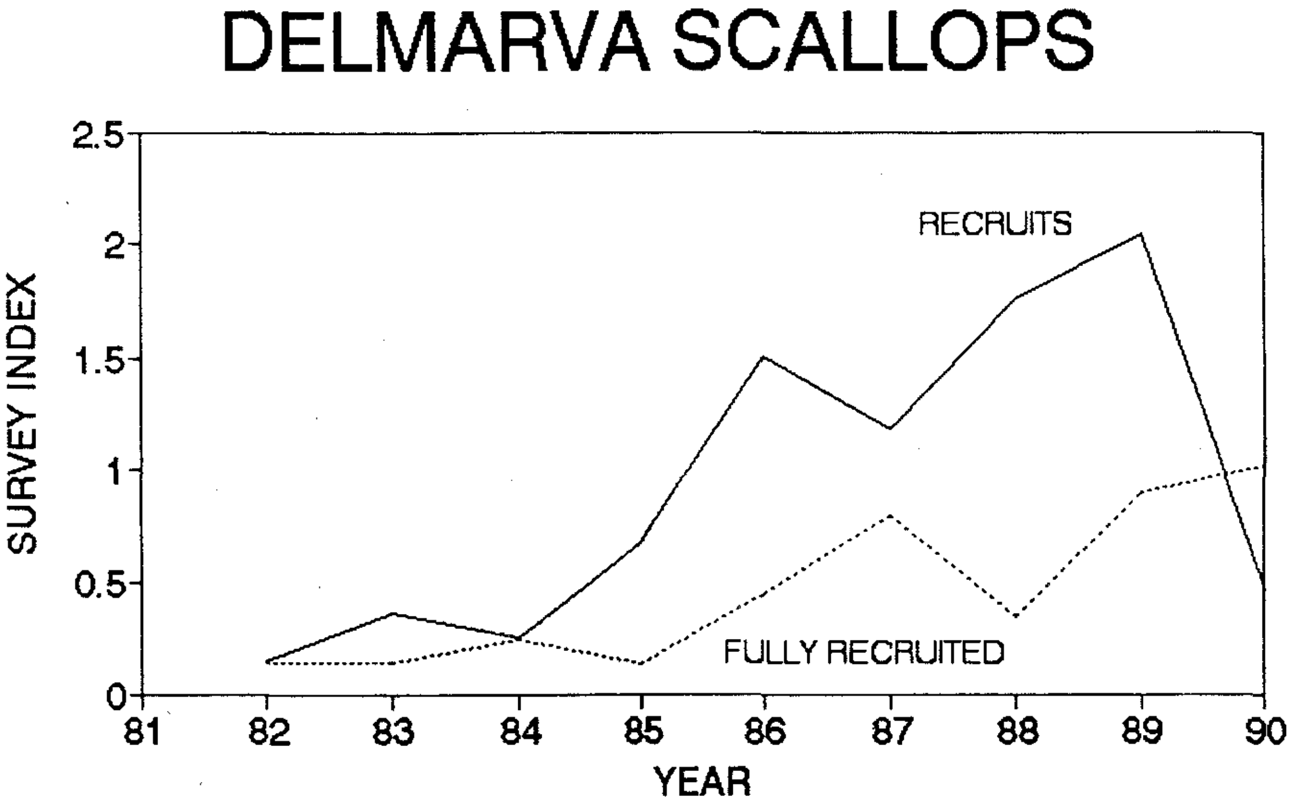

Figure AG4: Survey indices of partiially recruited (recruits) and fully recruited scallops in the Delmarva area. Indices are numbers per tow.

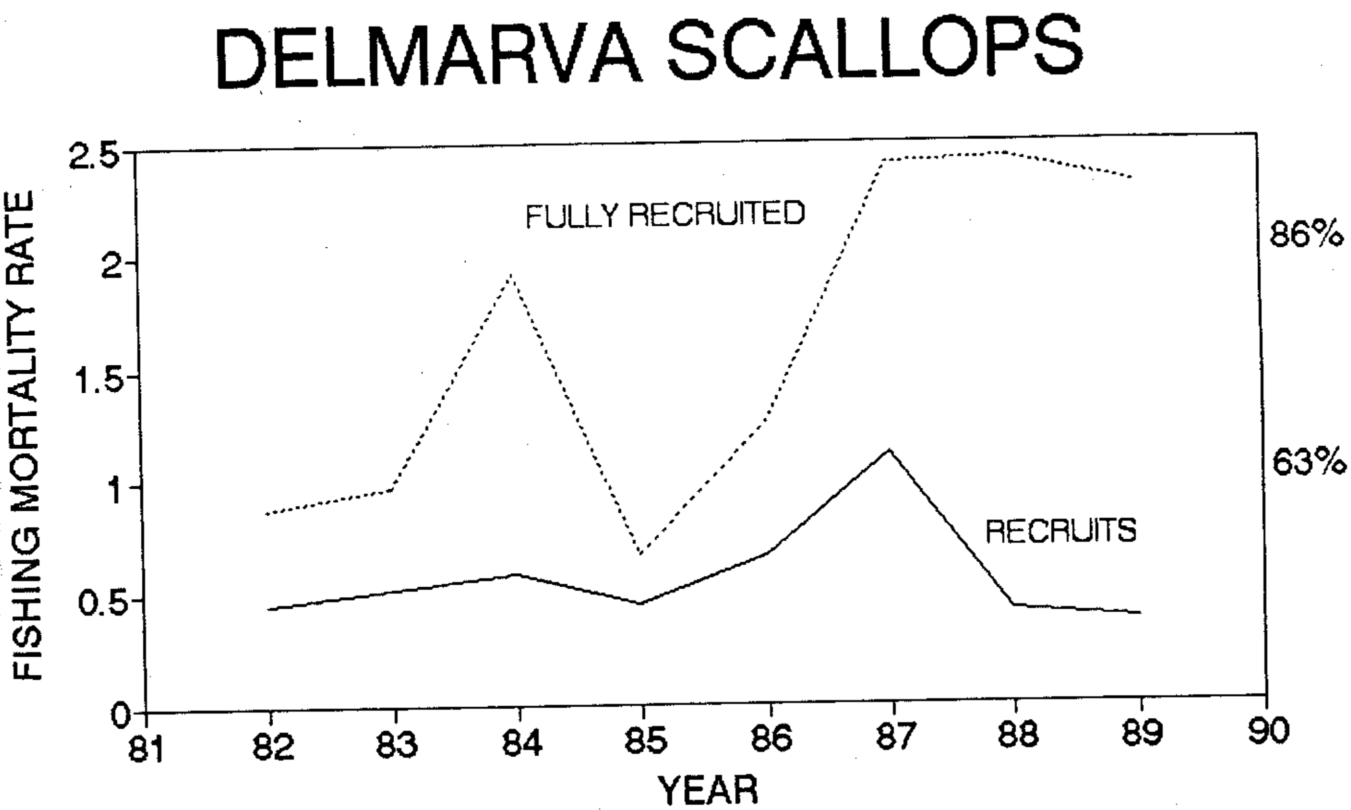

Figure AG5: Fishing mortality rates (left scale) and annual exploitation rates (right scale) for partiially recruited (recruits) and fully recruited scallops in the Delmarva area.

SAW-12 RESEARCH DOCUMENTS

SAW 12/1	Length Composition Analysis of Atlantic Sea Scallop Using the Multifan Method	M. Terceiro
SAW 12/2	A DeLury Model for Scallops Incorporating Length-Based Selectivity of the Recruiting Year-Class to the Survey Gear and Partial Recruitment to the Commercial Fishery	R. Conser
SAW 12/3	Current Resource Conditions in USA Georges Bank and Mid-Atlantic Sea Scallop Populations - Results of the 1990 NEFC Sea Scallop Research Vessel Survey	S. Wigley F. Serchuk
SAW 12/4	Stock Assessment of Atlantic Butterfish, <u>Peprilus triacanthus</u>, in the Northwest Atlantic	J. Brodziak
SAW 12/5	Stock Assessment of the Northwest Atlantic Mackerel Stock	W. Overholtz
SAW 12/6	Stock Assessment of Short-finned Squid, <u>Illex illecebrosus</u>, in the Northwest Atlantic	J. Brodziak
SAW 12/7	Stock Assessment of Long-Finned Squid, <u>Loligo pealei</u>, in the Northwest Atlantic	J. Brodziak
SAW 12/8	Bootstrap Estimators of Discard Rates Using Domestic Sea Sampling Data	J. Brodziak
SAW 12/9	Cod Discards in the Gulf of Maine Shrimp Fishery - An Exploration of the Sea Sampling Database	S. Wigley
SAW 12/10	By-catch and Discard Patterns in the Gulf of Maine Northern Shrimp Fishery	S. Clark G. Power
SAW 12/11	Exploratory Analysis of Four Methods for Estimating Discards from Sea Sampling Data	D. Hayes
SAW 12/12	An Assessment of the Southern New England and Georges Bank Yellowtail Flounder Stocks	R. Conser L. O'Brien W. Overholtz